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The Effect of Cooperative Learning Models on The Students' Mathematical Critical and Creative Thinking Ability: Meta-Analysis Study

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Abstract

This study aims to (1) describe the description of the results of the study of the influence of the implementation of cooperative learning models on students' mathematical critical and creative thinking abilities; (2) examine the implementation of the Cooperative learning model has a significant effect on students' critical and creative mathematical thinking abilities from the primary studies analyzed; (3) examine the differences in the implementation of the Cooperative learning model on students' critical and creative mathematical thinking skills in terms of educational level, sample size, and research demography from the primary studies analyzed. This research is quantitative research with a meta-analysis research design. The research sample that met the inclusion criteria consisted of 34 primary studies of mathematical critical thinking ability and 23 primary studies of mathematical creative thinking ability. The research findings found that the overall effect of implementing the cooperative learning model on the students' mathematical critical thinking skills had a significant effect with an effect size of 0.792. Overall, implementing the cooperative learning model on the students' mathematical creative thinking ability had a significant effect with an effect size of 0.696. In addition, there is no difference in mathematical creative, and critical thinking abilities between the students who studied in the cooperative class and those who studied other than in the cooperative class regarding education level and sample size. There is no difference in mathematical critical thinking skills between the students who studied in the cooperative class and those who studied other than in the cooperative class in research demography. However, there are differences in mathematical creative thinking abilities between the students who studied in the cooperative class and those who studied other than in the cooperative class regarding research demography.
Keywords: Mathematical Creative Thinking, Mathematical Critical Thinking, Cooperative, Meta-Analysis

Abstrak

Penelitian ini bertujuan untuk (1) mendeskripsikan hasil studi pengaruh dari implementasi model pembelajaran Kooperatif terhadap kemampuan berpikir kritis dan kreatif matematis siswa; (2) menguji implementasi model pembelajaran Kooperatif berpengaruh secara signifikan terhadap kemampuan berpikir kritis dan kreatif matematis siswa dari studi primer yang dianalisis; (3) menguji perbedaan dari implementasi model pembelajaran Kooperatif terhadap kemampuan berpikir kritis dan kreatif matematis siswa ditinjau dari jenjang pendidikan, ukuran sampel, dan demografi penelitian dari studi primer yang dianalisis. Penelitian ini penelitian kuantitatif dengan desain penelitian meta-analisis. Sampel penelitian yang memenuhi kriteria inklusi terdiri dari 34 studi primer kemampuan berpikir kritis matematis dan 23 studi primer kemampuan berpikir kreatif matematis. Berdasarkan temuan penelitian diperoleh bahwa secara keseluruhan pengaruh implementasi model pembelajaran kooperatif terhadap kemampuan berpikir kritis matematis siswa memberikan pengaruh yang positif dengan ukuran efek sebesar 0,792 dan secara keseluruhan pengaruh implementasi model pembelajaran Kooperatif terhadap kemampuan berpikir kreatif matematis siswa memberikan pengaruh yang positif dengan ukuran efek sebesar 0,696. Selain itu, tidak terdapat perbedaan kemampuan berpikir kritis maupun kreatif matematis siswa antara siswa yang belajar di kelas kooperatif dengan siswa yang belajar selain di kelas kooperatif ditinjau dari jenjang pendidikan dan ukuran sampel. Tidak terdapat perbedaan kemampuan berpikir kritis matematis siswa antara siswa yang belajar di kelas Kooperatif dengan siswa yang belajar selain di kelas Kooperatif ditinjau dari demografi penelitian. Namun, terdapat perbedaan kemampuan berpikir kreatif matematis siswa antara siswa yang belajar di kelas Kooperatif dengan siswa yang belajar selain di kelas Kooperatif ditinjau dari demografi penelitian.
Kata kunci: Berpikir Kreatif Matematis, Berpikir Kritis Matematis, Kooperatif, Meta-Analisis

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INTRODUCTION

The ability to think critically and creatively is an ability that students must master in the 21st century to bridge education that can provide progress to the Indonesian nation. Learning in the 2013 curriculum aims to develop 4C characters or 21st-century skills. Critical thinking and creative thinking are part of the 4C character (Critical Thinking Skills, Creative Thinking Skills, Communication Skills, and Collaboration Skills). The ability to think critically and think creatively can be formed through learning mathematics at school. It takes a model that can improve students' abilities; according to Widayati et al. (2018), ideally, learning mathematics in schools follows the learning model to achieve the learning objectives.

Learning Curriculum 2013 (K-2013) is designed to meet the trends of life in the 21st century. With the enactment of K-2013, there has been a shift regarding appropriate learning models to be developed to meet the demands of learning according to the provisions of K-2013. The cooperative learning model is a learning method appropriate to be developed in line with the learning needs in applying K-2013 (Ulfa & Rijanto, 2015). The characteristics of the Cooperative model are also able to develop students' critical and creative thinking skills. The main objective of cooperative learning is to maximize student learning to increase academic achievement and understanding both individually and as a group; because students work in a team, then by itself it can improve relations between students from various ethnic backgrounds and abilities, develop skills - group process skills and problem-solving (Trianto, 2012).

Research conducted by Rohani et al. (2022) showed that the Cooperative learning model has more influence in increasing the mathematical critical thinking skills of high school students on the island of Sumatra with a sample of more than 30 compared to conventional learning models. Likewise, the results of the research shown by Rahmawati & Sutarto (2014) stated that junior high school students in Java with a sample of less than 30 who were taught using the Cooperative model had more influence and significant gains on students' mathematical critical thinking skills compared to the Expository learning model. In addition, a study conducted by Sisnanto et al. (2019) stated that elementary school students in Java with a sample of more than 30 who were taught using the Cooperative model had a more significant influence than the Problem Posing learning model. This causes the acquisition of mathematical critical thinking skills to be higher than students who use learning other than the Cooperative learning model.

However, the results of other studies show conflict with the results of previous studies regarding the effect of cooperative learning models on mathematical critical thinking skills. The results of research conducted by Ansari et al. (2020) state that junior high school students on Sulawesi Island, with a sample of less than 30 who are taught using conventional learning models, have a more significant influence on mathematical critical thinking skills compared to the cooperative model. There is also research by Fadliyani (2016) on elementary school students on Sumatra Island with a larger sample equal to 30 and research by Tanjung, S. (2018) on high school students on Sumatra

Island with a larger sample similar to 30, which compares with the Contextual learning model. It was found that students critical thinking skills with Contextual learning had a more significant influence than the Cooperative learning model. In addition, another comparison of the Problem-Based Learning (PBL) learning model conducted by Ayudya & Rahayu (2020) shows that the critical thinking skills of elementary school students in Java with a sample smaller than 30 using PBL learning have a more significant influence than Cooperative learning.

Likewise, they get the Cooperative learning model to discover students' mathematical creative thinking. The creative thinking abilities of high school students on Maluku Island, with a sample of less than 30 who received the Cooperative learning model, were better than students who received the conventional learning model (Nur & Abdullah, 2014). Likewise, research by Yusra et al. (2021) shows that the Cooperative learning model provides more influential results on the creative thinking abilities of junior high school students on the island of Sumatra with a larger sample of 30 compared to the conventional learning model. In addition, research conducted by Atikasari & Kurniasih (2015) showed that the Cooperative learning model was more influential than Expository learning on the mathematical creative thinking abilities of junior high school students in Java Island with a sample more prominent than 30. Thus, the acquisition of mathematical creative thinking skills is higher than students who use learning other than cooperative learning models.

However, the results of other studies show conflict with the results of previous studies regarding the effect of the cooperative learning model on students' creative thinking abilities. As in the research conducted by Endriani & Rakhmawati (2019), the results of the study show that the creative thinking abilities of high school students on the island of Sumatra with a larger sample size equal to 30 using the Problem-Based Learning (PBL) learning model are more influential than the cooperative learning model. Not only in the PBL learning model but there is also a learning model other than Cooperative, namely the Contextual learning model, which significantly influences the creative thinking abilities of high school students on the island of Sumatra with a larger sample equal to 30.

These findings indicate that the effect of the cooperative learning model on students' mathematical creativity and critical thinking skills is not consistent, showing heterogeneous measures of effectiveness and therefore tends to describe the inconsistencies of the findings from one another. This inconsistency also results in subjective conclusions being drawn from different studies on the same topic (Paloloang et al., 2020). In addition, the intervention of the influence of several study characteristics causes the heterogeneity of the ability to think critically and creatively mathematically. According to Lipsey & Wilson (2001), this could be caused by several potential factors such as education level, sample size, research demographics, etc., which in previous studies had not been carried out in primary studies and could not even be answered by primer studies.

Factors that have the potential to cause this heterogeneity need to be investigated to provide clear and precise information. Therefore, the researcher wanted to see the effect of the cooperative learning model in terms of the characteristics of the study level of education, sample size, and research demography from studies of the cooperative learning model on students' mathematical critical and creative thinking abilities. The influence of study characteristics can strengthen or weaken the effect of a treatment.

Educational level is a characteristic of the study that needs to be considered because of its relationship to students' cognitive development condition. Applying the Cooperative learning model in learning will probably have more influence on students at a certain level, so these characteristics are interesting to analyze. This can be found in research conducted by Yunita et al. (2021) that there are differences in study effect sizes based on the educational level in the PjBL model. Added to the research by Paloloang et al. (2020) and Sari et al. (2018) that the application of PBL has an effect at the university level compared to the junior high and high school/vocational school levels. The level of education influences the application of the Discovery Learning learning model (Anjarwati et al., 2022). Likewise, in research conducted by Tamur et al. (2021), the application of STEM learning is influenced by educational level.

Furthermore, sample size can be a characteristic of the study considered for analysis because it refers to the policy of implementing education in Indonesia regarding the number of students per class. Classes with fewer students, equal to 30 people, with more than 30 students may provide different conduciveness. This can be proven in the results of Susanti et al. (2020) that in the application of PBL, there is a significant difference in effect sizes between groups according to sample size. For applying the Realistic Mathematics Education learning model based on sample size, researchers found that a small sample has a smaller effect size than a large sample (Maximus Tamur et al., 2020). Likewise for research conducted by Maximus Tamur & Juandi (2020) on the application of constructivism-based learning models, research conducted by Yunita et al. (2021) on the application of the Project-Based Learning learning model, research conducted by Tamur et al. (2021) on the application of the STEM learning model.

Then, the reasons for research demography can be used as study characteristics that can be considered for analysis because demography can cause differences in the culture of society on each island, giving rise to various factors that affect students' mathematical abilities. This is supported by research conducted by Suparman (2021) that research demography significantly causes heterogeneity in students' mathematical critical thinking skills through PBL. Likewise, Ramadhanti's (2022) research demography causes differences in students' higher-level mathematical thinking abilities through the PBL model.

Meta-analysis appears to overcome research problems in education, including mathematics education. Various study findings that initially seemed contradictory and challenging to accumulate eventually became more integrative and systematic through meta-analysis (Juandi & Tamur, 2021). Thus, integrating various study findings becomes an appropriate foundation for theory development, decision-making, and policy determination. Meta-analysis is a quantitative analysis that uses a large amount of data. It applies statistical methods by practicing them in organizing a large amount of information derived from large samples whose function is to complement other purposes to manage and extract as much information as possible from the data obtained, as well as a technique aimed at re-analyzing research results that are processed statistically based on primary data collection (Bloom et al., 2009; Glass, 1976; Hunter & Schmidt, 2004).

This meta-analysis research was conducted to determine the influence of the Cooperative learning model on students' mathematical creativity and critical thinking skills based on each independent study and a combination of these studies. This effect is expressed through the effect size, a metric unit in the meta-analysis that indicates the magnitude of the treatment effect or the strength of the relationship between two variables (Borenstein et al., 2009). It is also interpreted based on moderator variables or study characteristics, including education level, sample size, and research demographics. Based on the problems that have been described, researchers are interested in conducting research that aims to:

1. Does implementing the Cooperative learning model significantly affect the student's mathematical critical and creative thinking abilities from the primary studies being analyzed?
2. Is there a difference in implementing the Cooperative learning model towards the students' mathematical creative and critical thinking abilities in terms of educational level?
3. Is there a difference in implementing the Cooperative learning model on the students' mathematical critical and creative thinking abilities regarding sample size?
4. Is there a difference in implementing the Cooperative learning model on the students' mathematical critical and creative thinking abilities regarding research demography?

METHOD

Types Of Research

The method that can comprehensively analyze the primary study findings is the meta-analysis method. The meta-analysis is a systematic review using formal statistical analysis (Nindrea, 2016). This research was conducted to analyze statistical data from several primary studies on the same question, namely regarding the influence of the implementation of the cooperative learning model on students' mathematical creativity and critical thinking skills in Indonesia as a whole and in terms of several studies' characteristics. Following are the five main steps of this meta-analysis research adapted based on Decoster (2009):

1. Define the theoretical relationship of interest. Researchers need to examine the state of students' mathematical creative and critical thinking abilities if the implementation of cooperative learning is carried out.
2. It collects the research population through electronic search engines through primary studies on the theoretical relationship of interest. Then, select a list of primary studies that met the earlier inclusion criteria.

3. Perform data extraction and data coding by tabulating data. Then determine the size of the good effect on each study characteristic. This statistical calculation uses the help of the Comprehensive Meta-Analysis (CMA) Version 03 application.
4. Examine the distribution of effect sizes and impact analysis of moderator variables. At this stage, two steps are carried out, namely:
   a. The steps for testing publication bias on the data to be used are by looking at funnel plots, Trim and Fill tests, and Fail-Safe N (FSN). Suppose a primary study is found that must be ignored from the analysis. The calculation process is repeated after the partial data is removed from the CMA application input process.
   b. The identification step of the effect size heterogeneity test is seen from the value of the analysis process of the CMA application. Two possible conditions occur from the interpretation of heterogeneity test values, namely:

      First condition: If there is the heterogeneity of effect sizes, then the chosen estimation model uses the effects model and proceeds with analyzing each study characteristic.

      Second condition: If there is no effect size heterogeneity, then the estimation model chosen uses the fixed effects model and proceeds with step 5.
5. Interpret and report the results. At this stage, interpreting the results of the values obtained from the data analysis process using the CMA application is carried out. The interpretation is directed to answer the formulation of research problems and draw conclusions.

Inclusion Criteria

The description of the domain of inclusion criteria in this study uses the PICOS framework. PICOS can help facilitate the question-framing process (Liberati et al., 2009). The population (P) determined as the research topic was students at the education level of Elementary School, Junior High School, and Senior High School in Indonesia. Interventions (I) in the primary study studied the topic of this problem, namely the implementation of the Cooperative learning model as an experimental class in learning mathematics. Comparation (C) the intervention used in the primary study is applying a learning model other than cooperative as a control class. Outcomes (O) in the primary research used were the acquisition of scores in general for students' mathematical critical thinking skills or creative thinking abilities. The study design (S) used in the primary study is a quantitative research using experimental and quasi-experimental methods.

Apart from using the PICOS framework, other limitations in this study are:

1. Primary studies were published over the past ten years (2012-2022) and by Scopus-indexed journals and proceedings, Thomson Reuters, Sinta, Garuda, and Google Scholar.
2. The primary study provides complete information about study characteristics such as student education level, sample size, and research demographics.
3. The primary study provides statistical information for calculating effect sizes: mean value, standard deviation, sample size, t-value, and p-value.

Sample and Research Population

The population in this study were journal articles and proceedings obtained through the Publish or Perish 8 application electronic search engine. During the journal review of the search results, the researcher only entered published mathematics education research articles in an effort as a quality control measure. This search engine needs a search string so that the primary studies found are more specific and avoid acquiring too large a number. The research population obtained through the search engine was 357 primary studies of mathematical critical thinking skills and 272 primary studies of mathematical creative thinking abilities. The primary studies were then filtered using the inclusion criteria set by the researcher. The research sample that met the inclusion criteria consisted of 34 primary studies of mathematical critical thinking ability from 357 primary studies (the total effect size of the studies was 39) and 23 primary studies of mathematical creative thinking ability (the total effect size of the studies was 24).

Research Instruments

The instrument used in meta-analysis research to extract data is a coding form with specific categories. The data coding form is divided into two sections: (1) the coding section on statistical information related to empirical study findings needed to calculate effect sizes such as mean value, standard deviation, sample size, t-value, and p-value, (2) the coding section on information on study characteristics that match the study inclusion criteria, namely the level of student education, sample size, and research demographics.

Data analysis technique

The research meta-analysis represents each study's findings as an effect size. Effect size is statistical data that encodes important quantitative information from each relevant study finding (Bickman & Rog, 2001). Therefore, this study's data analysis technique used descriptive statistics to describe the effect size value and hypothesis testing using inferential Z statistics and Cochran Q statistics. Effect size is used to determine the number of groups that differ from other groups, to see the influence of the relationship between the independent variable to the dependent variable, to see consistency in the effect of the entire study, to answer the research hypothesis, and to make a summary.

The formula used to calculate the effect size of the Cooperative learning model on students' mathematical critical and creative thinking abilities is the Hedges' g formula which was chosen because this formula contains a more accurate effect size calculation due to the correction of values and using two independent groups. (Borenstein et al., 2009).

$$Hedges's\ g = \frac{\bar{X}_1 - \bar{X}_2}{S_{within}} \quad (1)$$

with

$$S_{within} = \sqrt{\frac{(n_1-1)S_1^2 + (n_2-1)S_2^2}{n_1+n_2-2}} \quad (2)$$

Information for $\bar{X}_1$ is the mean post-test scores of the experimental group; $\bar{X}_2$ is the mean post-test score of the control group; S_{within} is the standard deviation of the combined post-test score; S_1 is the standard deviation of the experimental group's post-test scores; S_2 is the standard deviation of the control group's post-test score; n_1 is the number of samples of the experimental group; n_2 is the number of samples in the control group. The g value obtained is interpreted in the effect size category, which is classified into five categories Juandi & Tamur (2020), presented in Table 1. below.

Table 1. Effect Size Category

Interval Effect Size (ES)	**Category**
$ES < 0{,}15$	Negligible effect
$0{,}15 \leq ES < 0{,}40$	Low effect
$0{,}40 \leq ES < 0{,}75$	Moderate effect
$0{,}75 \leq ES < 1{,}10$	High effect
$1{,}10 \leq ES < 1{,}45$	Very high effect
$ES \geq 1{,}45$	Perfect effect

In this meta-analysis research, to calculate and see the effect of each effect size of the meta-analysis study and the combined effect size of the entire survey are calculated. The calculation of the moderator variable (study characteristics) and the measurement of publication bias is completed with the help of the CMA. From the CMA application, we can find the value of g (effect size) in the Effect Size table and the 95% confidence interval in the Point estimate column.

RESULTS AND DISCUSSION

The primary study data was extracted in the coding form by the researcher, coding 1 and coding 2. Furthermore, the researcher conducted a reliability test using Cohens's Kappa (*k*) calculations on the results of the coding study between the two coding agents. Reliability testing was carried out with the help of the IBM SPSS Statistics 22 application on 19 items. The reliability test results indicated that all the items used in the coding were reliable to be used in the following stages of analysis in the primary study of mathematical critical thinking skills and creative thinking skills.

Results of Cooperative Learning Model Implementation on Students' Mathematical Critical Thinking Ability

The subsequent analysis was a publication bias test carried out using the results of the funnel plot, trim and fill values, and Fail-Safe N (FSN) values with the help of the Comprehensive Meta-Analysis (CMA) Version 03 application. The distribution of effect size data from each of the primary studies of mathematical critical thinking skills is presented in Figure 1.

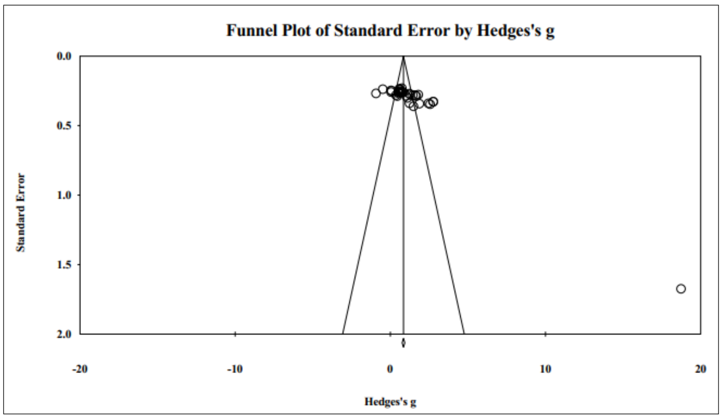

Figure 1. Funnel Plot of Students' Mathematical Critical Thinking Ability from Effect Size Hedge's g

Figure 1 interprets that the spread of the effect size distribution of the 39 primary studies in this study found that one effect size was located quite far away from the distribution of the other effect sizes, so it can be concluded that the combined effect size distribution was not completely symmetrical. Therefore, it is necessary to carry out a second publication bias test, trim and fill, to justify the results of the interpretation and analysis of the funnel plot. After the primary studies with codes A11, A27, A28, and A35 were excluded from this analysis, the trim and fill test was re-analyzed, showing that no more primary studies had to be excluded. Examination of the 39 primary studies found four primary studies to be excluded. Thus, it can be said that the other 35 primary studies are suitable for use in the next meta-analysis stage.

Based on the output of CMA version 03, the Fail-Safe N (FSN) value is 2,558, and then by manual calculation, it is obtained $\frac{FSN}{5K+10} = \frac{2.558}{5(35)+10} = \frac{2.558}{175+10} = \frac{2.558}{185} = 13{,}83$. Because the results are obtained $\frac{FSN}{5K+10} > 1$; hence it is interpreted that there is no publication bias for the primary study of this meta-analysis. Thus, analyzing publication bias with FSN values can strengthen the trim and fill test results that 35 primary studies can use in this study.

After finding the results of the publication bias test, namely, as many as 35 primary studies were resistant to publication bias, the subsequent analysis was to identify the heterogeneity of the effect size distribution. Information related to the heterogeneity test can be identified through the output of the Comprehensive Meta-Analysis (CMA) Version 03 application. Based on the interpretation of Cochran's Q value or p-value, the results show that the result is rejected H_0 i.e., there is significant heterogeneity. It is said that there is heterogeneity if $Q_{hitung} > \chi^2_{(df;0{,}05)}$ or $p-value < 0{,}05$. The results of this primary data heterogeneity test show $188{,}179 > 48{,}6024$ or $0{,}000 < 0{,}05$, then the estimation model that fits these conditions is the random effects model. When the effect size is statistically heterogeneous, there is a statistically significant difference in the mean effect size for each study or group of study characteristics. Information on the effect size of the primary study on the influence of the cooperative learning model on mathematical critical thinking skills with the random effects model estimation model is presented in Table 2. below.

Table 2. Effect Size of Students' Mathematical Critical Thinking Ability Based on the Random Effect Model

Number of Primary Studies	**Null Hypothesis Test**		**Effect Size and 95% Confidence Interval**				
	$p-value$	$Z-value$	**Effect Size**	**Standard Error**	**Variants**	**Lower Limit Variance**	**Upper Limit**
35	0,000	7,413	0,792	0,107	0,011	0,582	1,001

Analysis of this hypothesis was carried out using the p-value of the Z statistic, obtained $p-value = 0{,}000 < 0{,}05$; it can be interpreted that it is proven that the application of cooperative learning models has a positive influence on students' mathematical critical thinking skills than the application of learning models other than cooperative learning. The formula used to calculate the effect size of the Cooperative learning model on students' mathematical critical thinking skills is Hedge's g formula. Table 2. shows that overall the effect size of the cooperative learning model on students' mathematical critical thinking skills is $g = 0.792$, and the effect size is categorized into the influence currently in the categorization of Juandi & Tamur (2020).

Effect Size Viewed from Study Characteristics

In this meta-analysis study, educational level was the first study characteristic to be analyzed. The moderator variable based on the educational level in this primary study is based on the Indonesian National Education System, namely Elementary School, Junior High School, and Senior High School. Information related to the heterogeneity test of educational level characteristics can be identified through the output of the Comprehensive Meta-Analysis (CMA) Version 03 application. Based on the interpretation of Cochran's Q value or p-value, the results show that H_0 i.e., there is no significant heterogeneity. It is said that there is no heterogeneity if $Q_{hitung} < \chi^2_{(df;0{,}05)}$ or $p-value > 0{,}05$. This primary data heterogeneity test results show $0{,}625 < 5{,}9915$ or $0{,}731 > 0{,}05$. These findings do not show the characteristics of the educational level causing weak, moderate, and strong levels of students' mathematical critical thinking skills through the cooperative learning model. These findings indicate that the characteristics of educational level are not a factor in causing differences in students' mathematical critical thinking abilities through cooperative learning models.

This means that the influence of the implementation of cooperative learning models on students' mathematical critical thinking skills is not dominant at certain educational levels. This interprets that the level of difficulty of the math topic and the characteristics of the math topic has been arranged and designed in such a way as to suit the cognitive development of students. It can be concluded that the difficulty level of a math topic at an educational level is balanced with the ability of students at an educational level to learn it. Information on the effect size of the primary study on the effect of the cooperative learning model on the ability to think critically mathematically from the characteristics of the educational level is presented in Table 3. below.

Table 3. Effect Size of Students' Mathematical Critical Thinking Ability from Educational Level Characteristics

Study Characteristics	**Classification**	**Number of Primary Studies**	**Effect Size**	**Null Hypothesis Test**	
				$p - value$	$Z - value$
Educational Stage	Elementary School	7	0,766	0,000	7,169
	Junior High School	20	0,743	0,000	12,555
	Senior High School	8	0,667	0,000	7,176

Based on Table 3., it is found that the effect size for the elementary school level is 0.766 with a high effect category. Furthermore, the effect size for junior high school education is 0.743, with a moderate effect category. Then, the effect size for the high school education level is 0.667, with an intermediate effect category. For each characteristic of the educational level study, the p-value of the Z statistic is obtained $0{,}000 < 0{,}05$; it can be interpreted that it is proven that the application of cooperative learning models at the elementary, junior high, and high school education levels have a positive influence on students' mathematical critical thinking skills than the application of learning models other than cooperative learning.

The second study characteristic analyzed was the sample size. The moderator variable based on the sample size in this primary study was classified into a sample size of less than 30 and more than or equal to 30. Information related to the heterogeneity test of the sample size characteristics can be identified through the output results of the Comprehensive Meta-Analysis (CMA) Version application 03. Based on the interpretation of Cochran's Q value or p-value indicates that the result is acceptable H_0 i.e., there is no significant heterogeneity. It is said that there is no heterogeneity if $Q_{hitung} < \chi^2_{(df;0,05)}$ or $p - value > 0{,}05$. This primary data heterogeneity test results show $0{,}137 < 3{,}8415$ or $0{,}712 > 0{,}05$. These findings do not show the characteristics of the sample size causing weak, moderate, and strong levels of students' mathematical critical thinking skills through cooperative learning models. These findings indicate that the characteristics of the sample size are not a factor in causing differences in students' mathematical critical thinking skills through the cooperative learning model.

This means that the influence of the implementation of cooperative learning models on students' mathematical critical thinking skills is not dominant at a specific sample size. This can be caused by a good teacher's ability to manage the class so that learning activities can be handled in a class with many students and be more effective and less tiring. Information on the effect size of the primary study on the effect of the cooperative learning model on mathematical critical thinking skills from the sample size characteristics is presented in Table 4. below.

Table 4. Effect Size of Students' Mathematical Critical Thinking Ability from Sample Size Characteristics

Study Characteristics	**Classification**	**Number of Primary Studies**	**Effect Size**	**Null Hypothesis Test**	
				$p-value$	$Z-value$
Sample Size	< 30	7	0,764	0,000	7,169
	>=30	26	0,721	0,000	7,176

Based on Table 4., it is found that the effect size for a sample size of less than 30 is 0.764 with a high effect category. Furthermore, the effect size for a sample size of more than or equal to 30 is 0.721 with a moderate effect category, and the p-value of the Z statistic is obtained $0{,}000 < 0{,}05$; then it can be interpreted that it is proven that the application of cooperative learning models. In each study characteristic, the sample size is less than 30, and the sample size is more than or equal to 30. It positively affects students' mathematical critical thinking skills rather than the application of learning models other than cooperative learning.

The last study characteristic to be analyzed is the demography of the research. The moderator variable based on research demography in this primary study is classified into Sumatra, Java, Kalimantan, Sulawesi, Bali, and Nusa Tenggara, Maluku islands Papua. Information related to the heterogeneity test of the demographic characteristics of the study can be identified through the output of the Comprehensive Meta-Analysis (CMA) Version 03 application. Based on the interpretation of the Cochran Q value or p-value, the results show that H_0 i.e., there is no significant heterogeneity. It is said that there is no heterogeneity if $Q_{hitung} < \chi^2_{(df;0{,}05)}$ or $p-value > 0{,}05$. This primary data heterogeneity test results show $1{,}138 < 9{,}4877$ or $0{,}888 > 0{,}05$. These findings do not show the demographic characteristics of the research causing weak, moderate, and strong levels of students' mathematical critical thinking skills through the cooperative learning model. These findings indicate that the demographic characteristics of the study are not a factor in causing differences in students' mathematical critical thinking skills through the cooperative learning model.

This means that the influence of implementing the cooperative learning model on students' mathematical critical thinking skills is not dominant in demographic research. This can be due to the uneven implementation of the cooperative learning model and a lot of training on cooperative learning models for every teacher on every island. Forming the subject-teacher consultation also helps the socialization of the cooperative learning model for every mathematics subject teacher become easier. With so much socialization and training, teachers are getting used to applying cooperative learning models in learning mathematics to improve students' critical mathematical abilities. This causes the effect of the cooperative learning model on mathematical critical thinking skills in each region to be relatively the same. Information on the effect size of the primary study on the influence of the cooperative learning model on mathematical critical thinking skills from the research demographic characteristics is presented in Table 5. below.

Tabel 6. *Effect Size* Kemampuan Berpikir Kritis Matematis Siswa Dari Karakteristik Demografi Penelitian

Study Characteristics	**Classification**	**Number of Primary Studies**	**Effect Size**	**Null Hypothesis Test**	
				$p-value$	$Z-value$
Research Demographics	Sumatera	9	0,668	0,000	7,488
	Jawa	19	0,750	0,000	12,130
	Kalimantan	1	0,686	0,008	2,658
	Sulawesi	4	0,818	0,000	5,974
	Bali and Nusa Tenggara	2	0,673	0,000	3,881

Based on Table 5., it was found that the effect size for the Sumatra research demographic was 0.668 with a moderate effect category. Furthermore, the effect size for the Javanese research demographic is 0.750, with a high effect category. Then, the influence (effect size) for the demographics of the Kalimantan study was 0.686 with a moderate effect category. Then, the influence (effect size) for the research demographics of Sulawesi is 0.818 with a high effect category. Furthermore, the influence (effect size) for the Bali and Nusa Tenggara research demographics was 0.673 with a moderate effect category. In each of the characteristics of the demographic research study, the p-value of the Z statistic was obtained $0{,}000 < 0{,}05$; it can be interpreted that it is proven that the application of the cooperative learning model to the research demographics of Sumatra, Java, Kalimantan, Sulawesi, as well as Bali and Nusa Tenggara has a positive influence on students' mathematical critical thinking skills than the application of learning models other than cooperative learning.

Results of Cooperative Learning Model Implementation on Students' Mathematical Creative Thinking Ability

The subsequent analysis was a publication bias test carried out using the results of the funnel plot, trim and fill values, and Fail-Safe N (FSN) values with the help of the Comprehensive Meta-Analysis (CMA) Version 03 application. The distribution of effect size data from each of the primary studies of mathematical creative thinking skills is presented in Figure 1.

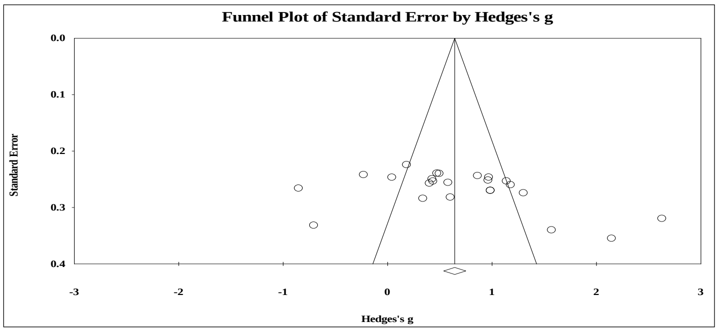

Figure 2. Funnel Plot of Students' Mathematical Creative Thinking Ability from Hedge's Effect Size g

Figure 2 interprets that the spread of the effect size distribution of the 24 primary studies in this study is symmetrical on the left and right on the funnel plot in the form of a vertical line. So, these findings indicate that the collection of effect sizes from each primary study has a small risk of publication bias (Borenstein et al., 2009). The trim and fill test results interpret that the studies that should be excluded or cut from this analysis are zero primary studies. These findings indicate that no primary studies or effect sizes were excluded from this meta-analysis. So, it can be said that the 24 primary studies can be used in the next meta-analysis stage.

Based on the output of CMA version 03, the Fail-Safe N (FSN) value is 737; then, with manual calculations, it is obtained $\frac{FSN}{5K+10} = \frac{938}{5(24)+10} = \frac{938}{120+10} = \frac{938}{130} = 7{,}215$. Because the results are obtained $\frac{FSN}{5K+10} > 1$; hence it is interpreted that there is no publication bias for the primary study of this meta-analysis. Thus, analyzing publication bias with FSN values can strengthen the trim and fill test results that 24 primary studies can use in this study.

After finding the results of the publication bias test, namely, as many as 24 primary studies were resistant to publication bias, the subsequent analysis was to identify the heterogeneity of the effect size distribution. Information related to the heterogeneity test can be identified through the output of the Comprehensive Meta-Analysis (CMA) Version 03 application. Based on the interpretation of Cochran's Q value or p-value, the results show that the H_0 i.e., there is significant heterogeneity. It is said that there is heterogeneity if $Q_{hitung} > \chi^2_{(df;0{,}05)}$ or $p - value < 0{,}05$. The results of this primary data heterogeneity test show $160{,}424 > 35{,}1725$ or $0{,}000 < 0{,}05$, then the estimation model that fits these conditions is the random effects model. When the effect size is statistically heterogeneous, there is a statistically significant difference in the mean effect size for each study or group of study characteristics. Information on the effect size of the primary study on the effect of the cooperative learning model on the ability to think creatively mathematically with the estimation model of the random effects model is presented in Table 6 below.

Table 6. Effect Size of Students' Mathematical Creative Thinking Ability Based on the Random Effect Model

Number of Primary Studies	**Null Hypothesis Test**		**Effect Size and 95% Confidence Interval**				
	$\boldsymbol{p - value}$	$\boldsymbol{Z - value}$	**Effect Size**	**Standard Error**	**Variants**	**Lower Limit Variance**	**Upper Limit**
24	0,000	4,865	0,696	0,143	0,020	0,415	0,976

Analysis of this hypothesis was carried out using the p-value of the Z statistic, obtained $p - value = 0{,}000 < 0{,}05$; it can be interpreted that it is proven that the application of cooperative learning models has a positive influence on students' mathematical creative thinking abilities than the application of learning models other than cooperative learning. The formula used to calculate the effect size of the cooperative learning model on students' mathematical creative thinking abilities is

Hedge's g formula. Table 6. shows that overall the effect size of the cooperative learning model on students' mathematical creative thinking abilities is $g = 0{,}696$, and the magnitude of the effect size is categorized into the effect being organized by Juandi & Tamur (2020).

Effect Size Viewed from Study Characteristics

In this meta-analysis study, educational level was the first study characteristic to be analyzed. The moderator variable based on the educational level in this primary study is based on the Indonesian National Education System, namely Elementary School, Junior High School, and Senior High School. Information related to the heterogeneity test of educational level characteristics can be identified through the output of the Comprehensive Meta-Analysis (CMA) Version 03 application. Based on the interpretation of Cochran's Q value or p-value, the results show that H_0 i.e., there is no significant heterogeneity. It is said that there is no heterogeneity if $Q_{hitung} < \chi^2_{(df;0,05)}$ or $p - value > 0{,}05$. This primary data heterogeneity test results show $0{,}028 < 3{,}8415$ or $0{,}867 > 0{,}05$. These findings do not show the characteristics of the level of education causing weak, moderate, and strong levels of students' mathematical creative thinking abilities through cooperative learning models. These findings indicate that the characteristics of educational level are not a factor in causing differences in students' mathematical creative thinking abilities through cooperative learning models.

This means that the influence of the implementation of cooperative learning models on students' mathematical critical thinking skills is not dominant at certain educational levels. This interprets that the level of difficulty of the math topic and the characteristics of the math topic has been arranged and designed in such a way as to suit the cognitive development of students. This means that the difficulty level of a math topic at an educational level is balanced with the ability of students at an educational level to learn it.

The primary study of mathematical creative thinking abilities was found only at the junior and senior high school levels. For the elementary school level, there was no primary study that met the inclusion criteria. Information on the effect size of the primary study on the effect of the cooperative learning model on the ability to think creatively mathematically from the characteristics of the educational level is presented in Table 7. below.

Table 7. Effect Size of Students' Mathematical Creative Thinking Ability from Educational Level Characteristics

Study Characteristics	**Classification**	**Number of Primary Studies**	**Effect Size**	**Null Hypothesis Test**	
				$p - value$	$Z - value$
Educational Stage	Junior High School	17	0,637	0,000	10,037
	Senior High School	7	0,657	0,000	6,431

Based on Table 7., it is found that the effect size for junior high school education is 0.637 with a moderate effect category. Then, the effect size for the high school education level is 0.657 with an intermediate effect category. For each characteristic of the educational level study, the p-value of the Z statistic is obtained at $0{,}000 < 0{,}05$; it can be interpreted that it is proven that the application of cooperative learning models at the junior and senior high school education levels has a positive influence on students' mathematical creative thinking abilities than the application of learning models other than cooperative learning.

The second study characteristic analyzed was the sample size. The moderator variable based on sample size in this primary study was classified into a sample size of less than 30 and more than or equal to 30. Information related to the heterogeneity test of sample size characteristics can be identified through the output results of the Comprehensive Meta-Analysis (CMA) Version application 03. Based on the interpretation of Cochran's Q value or p-value indicates that the result is acceptable H_0 i.e., there is no significant heterogeneity. It is said that there is no heterogeneity if $Q_{hitung} < \chi^2_{(df;0{,}05)}$ or $p - value > 0{,}05$. This primary data heterogeneity test results show $1{,}567 < 3{,}8415$ or $0{,}211 > 0{,}05$. These findings do not show the characteristics of the sample size causing weak, moderate, and strong levels of students' mathematical creative thinking abilities through cooperative learning models. These findings indicate that the characteristics of the sample size are not a factor in causing differences in students' mathematical creative thinking abilities through cooperative learning models.

This means that the influence of implementing cooperative learning models on students' mathematical creative thinking abilities is not dominant at a specific sample size. This can be caused by a good teacher's ability to manage the class, so that learning activities can be handled in a class with many students so that they can be more effective and less tiring. Information on the effect size of the primary study on the effect of the cooperative learning model on the ability to think creatively mathematically from the sample size characteristics is presented in Table 8. below.

Table 8. Effect Size of Students' Mathematical Creative Thinking Ability from Sample Size Characteristics

Study Characteristics	**Classification**	**Number of Primary Studies**	**Effect Size**	**Null Hypothesis Test**	
				$p - value$	$Z - value$
Sample Size	< 30	4	0,834	0,000	5,161
	>= 30	20	0,619	0,000	10,824

Table 8 shows that the effect size for a sample size of less than 30 is 0.834 with a high effect category. Furthermore, the effect size for a sample size of 0.619 is greater than or equal to 0.619 in the moderate effect category. For each characteristic of the educational level study, the p-value of the Z statistic is obtained $0{,}000 < 0{,}05$; it can be interpreted that it is proven that the application of the cooperative learning model to a sample size of less than 30 and a sample size of more than or equal to 30 has a positive influence on students' mathematical creative thinking abilities than the application of learning models other than cooperative learning.

The last study characteristic to be analyzed is the demography of the research. The moderator variable based on research demography in this primary study is classified into the islands of Sumatra, Java, Kalimantan, Sulawesi, Bali and Nusa Tenggara, Maluku, and Papua. Information related to the heterogeneity test of the demographic characteristics of the study can be identified through the output of the Comprehensive Meta-Analysis (CMA) Version 03 application. Based on the interpretation of the Cochran Q value or p-value, the results show that H_0 i.e., there is no significant heterogeneity. It is said that there is no heterogeneity if $Q_{hitung} < \chi^2_{(df;0,05)}$ or $p - value > 0{,}05$.

This primary data heterogeneity test results show $15{,}892 > 7{,}8147$ or $0{,}001 < 0{,}05$. These findings show that the demographic characteristics of the research lead to weak, moderate, and strong levels of students' mathematical creative thinking abilities through cooperative learning models. These findings indicate that the research's demographic characteristics are one factor in causing differences in students' mathematical creative thinking abilities through the cooperative learning model.

Information on the effect size of the primary study on the influence of the cooperative learning model on the ability to think creatively mathematically from the demographic characteristics of the research is presented in Table 9. below.

Table 9. Effect Size of Students' Mathematical Creative Thinking Ability from Research Demographic Characteristics

Study Characteristics	**Classification**	**Number of Primary Studies**	**Effect Size**	**Null Hypothesis Test**	
				$p - value$	$Z - value$
Research Demographic	Sumatera	14	0,531	0,000	7,413
	Jawa	8	0,681	0,000	7,686
	Sulawesi	1	1,305	0,000	4,749
	Maluku	1	1,574	0,000	4,624

Based on Table 9., it was found that the effect size for the Sumatra research demographic was 0.531 with a moderate effect category. Furthermore, the effect size for the Javanese research demographic is 0.681, with an intermediate effect category. Then, the influence (effect size) for the research demographics of Sulawesi was 1.305, with a very high effect category. Furthermore, the effect size for the Maluku research demographic was 1.574, with a perfect effect category. In each of the characteristics of the demographic research study, the p-value of the Z statistic was obtained $0{,}000 < 0{,}05$; it can be interpreted that it is proven that the application of the cooperative learning model to the research demographics of Sumatra, Java, Sulawesi, and Maluku has a positive influence on students' mathematical creative thinking abilities rather than the application of learning models other than cooperative learning.

Other meta-analysis studies analyzed the influence (effect size) of the cooperative learning model on mathematics learning in general. Research conducted by Nurjanah & Arifin (2022) gives an effect size of $g = 1.09$ in the high effect category. Then, it was found in research conducted by Sholeka & Zainudin (2020) gives an effect size of $g = 0.158$ in the low effect category. Then, it was found in the study conducted by Chindiani (2021) the influence (effect size) of the cooperative learning model on problem-solving abilities gives an effect size of $g = 0.998$ in the high effect category.

In other meta-analytical studies, it was also found that the effect size of the implementation of cooperative learning models on students' mathematical critical thinking abilities was in the medium category, namely $g = 0.683$ (Leniati & Indarini, 2021). Thus, information is obtained that the effect size obtained from other meta-analytical studies on the study of mathematical critical thinking skills is at a moderate level.

Furthermore, a meta-analysis study was found related to the influence of various learning models on the ability to think mathematically creatively, which gives an effect size of $g = 1.26$ in the very high effect category (Widodo et al., 2021). The other meta-analysis studies provide an effect size of $g = 0.455$ in the moderate effect category (Damanik et al., 2021). Thus, information is obtained that the effect size obtained from other meta-analysis studies on the study of mathematical creative thinking ability is at very high and moderate levels.

In other meta-analytical studies, let us compare the effect size of students' mathematical critical thinking skills and mathematical creative thinking skills. It can be concluded that studies on students' mathematical creative thinking abilities are higher than students' mathematical critical thinking skills in general. This conclusion differs from this meta-analysis study which, when viewed from the effect size. Based on the findings of this meta-analysis study, the effect size in the study of students' mathematical critical thinking skills was $g = 0.792$, which was greater than that in the study of students' mathematical creative thinking abilities, $g = 0.696$.

CONCLUSION

Based on the findings and discussion in this meta-analysis research, which includes the effect of implementing cooperative learning models on critical and creative mathematical thinking skills, it can be concluded that implementing the Cooperative learning model positively influences students' mathematical critical thinking skills. The effect size of $g = 0.792$ is categorized into moderate influence. Likewise, the implementation of the Cooperative learning model has a positive influence on students' mathematical creative thinking abilities. The effect size of $g = 0.696$ is categorized into moderate influence.

There is no difference in the effect of implementing the cooperative learning model on students' critical and creative mathematical thinking skills in terms of the overall level of education and at each level of junior high school and high school education. There is no difference in the effect of implementing the Cooperative learning model on students' critical thinking skills and creative mathematical thinking regarding sample size. There is no difference in the impact of implementing the Cooperative learning model on students' mathematical critical thinking skills in terms of research demographics. However, there are differences in the effect of implementing the Cooperative learning model on students' mathematical creative thinking abilities regarding research demographics.

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