INDONESIAN JOURNAL OF EDUCATIONAL RESEARCH AND REVIEW
Volume 7 Nomor 3 2024, pp 630-642
E-ISSN: 2621-8984; P-ISSN: 2621-4792
DOI: https://doi.org/10.23887/ijerr.v7i3.80331

Assessing the Correlation Between Creative Thinking and Mathematics Learning Success: A Meta-Analytical Perspective

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Abstrak

Kreativitas berpikir merupakan keterampilan yang perlu dimiliki peserta didik dalam pembelajaran matematika. Para peneliti pendidikan telah menemukan hubungan yang tidak konsisten antara berpikir kreatif dengan keberhasilan belajar matematika. Tujuan penelitian meta-analisis ini yaitu untuk mengetahui hubungan berpikir kreatif dengan keberhasilan belajar matematika secara simultan. Penelitian ini adalah kajian kuantitatif yang menggunakan data dari studi-studi primer yang telah publish di jurnal. Sampel dikumpulkan dengan bantuan aplikasi publish or perish, sehingga diperoleh 14 artikel yang memenuhi kriteria. Data yang diperoleh dianalisis menggunakan meta-analisis korelasi dengan bantuan aplikasi JASP. Berdasarkan hasil analisis data disimpulkan bahwa korelasi kreativitas berpikir dengan keberhasilan belajar matematika berada pada kategori kuat. Di samping itu ukuran efek korelasi kreativitas berpikir dengan keberhasilan matematika antar jenjang pendidikan dan antara sampel ukuran kecil dengan sampel ukuran besar berbeda secara signifikan. Namun tidak terdapat perbedaan signifikan ukuran efek korelasi kreativitas berpikir dengan keberhasilan belajar matematika berdasarkan tahun publikasi. Oleh karena itu diharapkan agar proses pembelajaran matematika perlu memperhatikan pengembangan keterampilan berpikir kreatif.

***Kata kunci**: Berpikir Kreatif, Keberhasilan Belajar, Matematika*

Abstract

Creative thinking is a critical skill for students to develop in mathematics learning. Educational researchers have found an inconsistent relationship between creative thinking and success in mathematics learning. This meta-analysis aims to determine the overall relationship between creative thinking and mathematics learning success. The study employed a quantitative approach, utilizing data from primary studies published in academic journals. The sample was collected using the Publish or Perish application, resulting in 14 articles that met the inclusion criteria. The data were analyzed using correlation meta-analysis with the assistance of the JASP application. The analysis revealed that the correlation between creative thinking and mathematics learning success falls into the strong category. Additionally, the effect size of the correlation differed significantly across educational levels and between small and large sample sizes. However, no significant differences were observed in the effect size of the correlation based on the year of publication. These findings highlight the importance of fostering creative thinking skills in the mathematics learning process to enhance students' academic success.

Keywords: Thinking Creativity, Learning Success, Mathematics

History:
Received : June 11, 2024
Accepted : September 16, 2024
Published : October 25, 2024

Publisher: Undiksha Press

1. INTRODUCTION

Thinking is one of the human existences that distinguishes it from other creatures. Without the ability to think, man cannot do anything well. Various ideas can be generated by humans in managing life on Earth because they can think (Hilman & Mainaki, 2020; Lestari et al., 2022). The development of science and technology is the result of thinking. To maintain and strengthen this existence, humans carry out the educational process, both formally and informally. Education is expected to be able to produce human resources who can think. Global competition and rapidly developing technology require countries and societies to develop themselves through education. 21st-century education emphasizes the development of students' thinking skills (Akgül & Kahveci, 2017; Miyatun et al., 2021). One of the thinking skills developed is the ability to think creatively. Bloom's taxonomy, which is widely referenced in the learning process, has been revised to place the element of creativity at the highest level. In Indonesia, the mandate of developing creative thinking skills is explicitly stated in Article 3 of the National Education System Law Number 20 of 2003 (Assaly & Smadi, 2015; Bili et al., 2022). The mandate of the law illustrates that creative thinking skills should not be neglected in education. The ability to think creatively also determines the superiority of a nation. Creativity is the potential of every student, but not all creativity becomes a skill (La Moma, 2015; Tahir & Marniati, 2018). Creative thinking is the ability to think higher order. Therefore, learning carried out in class needs to be packaged in such a way that the creative thinking process can develop. Creative thinking skills can develop well in a supportive environment. That is, the learning process must provide sufficient space for the development of students' thinking creativity. This can be achieved by applying pressing learning to the problem-solving process.

The creativity of one's thinking can be seen in one's ability to produce something new that is different from what already exists. Thinking creativity is a mental activity related to sensitivity to a problem, considering new information and ideas that are unusual using an open mind, and being able to make connections in problem-solving (Nehe et al., 2017; Rizqi et al., 2019). The creative thinking skills possessed by a person can be seen in fluency, flexibility, originality, and elaboration (Leikin & Lev, 2013; Nehe et al., 2017; Trisnayanti et al., 2020). The aspect of fluency in thinking can be seen in a person's ability to make various ideas or suggestions for solving a problem, ask many questions, and think of many solutions. The flexibility aspect of creative thinkers can be seen from their ability to examine a problem from various points of view and easily find many alternative solutions. The aspect of originality is seen in the ability to propose new ideas, new ways or procedures, or synthesize various elements that produce new and unique things (Miyatun et al., 2021; Trisnayanti et al., 2020). The elaboration aspect is seen from being able to make detailed ideas about an object or state, add, develop, and enrich an idea or idea.

Students who have creative thinking skills can study a problem diligently, ask questions, and come up with various ideas to produce innovative procedures to find original solutions. In addition, students who have creative thinking skills can produce new ideas that are predictable, useful, and adaptive to the challenges of the tasks they face (Runco & Jaeger, 2012; Sugianto et al., 2018). Students who have creative thinking skills are not easily discouraged and always try to find ways or procedures for solving a problem to find possible solutions. Thus, students who can think creatively will easily solve the various challenges they face, especially in the learning process.

Mathematics is one of the subjects that can develop creative thinking skills. For this reason, mathematics is set as a compulsory subject that must be studied by students at all levels of education (Meika et al., 2021; Wahyuni & Kurniawan, 2018). One of the characteristics of mathematics is the connection between various concepts and complexes. To understand mathematics requires creative thinking skills. To achieve competence in mathematics learning requires the ability to think creatively (Santoso et al., 2014; Siswono, 2004). Creativity thinking has an important role in learning mathematics. With creative thinking, students can generate various new ideas in learning mathematics. The ability to think creatively is needed to determine the appropriate way or procedure to solve mathematical problems from simple to complex problems (Mualifah et al., 2020; Prihatiningsih & Ratu, 2020). Creative thinking allows students to find unique and different ideas, especially in solving a mathematical problem.

Creative learners can deal with mathematical situations smoothly, flexibly, with broad-minded, and originality, they can use appropriate mathematical knowledge and processes with other mathematical tasks and problems (Kattou et al., 2013; Nurlaela et al., 2018). Therefore, if learning is designed to develop students' creative thinking skills, then they will more easily understand mathematics along with the development of their abilities.

Mathematics which is often considered difficult will slowly turn into fun because creative thinking makes students not fixated with standard ways or procedures that already exist. They will generate and use new ideas, be imaginative, and be confident, thus learners who have creative thinking skills can obtain good mathematics learning results.

The reality in the field shows that the creativity of thinking in mathematics of Indonesian children is still low (Supardi U.S., 2012; Susilawati et al., 2020).. Low creativity in learning to think mathematically can affect the success of learning mathematics students. Although the success of learning mathematics is influenced by many factors, creativity in thinking is one aspect that contributes. For students who have high thinking creativity, learning outcomes are also high, and vice versa. Low creativity in thinking can have implications for low achievement of mathematics learning outcomes (Kattou et al., 2013; Susilawati et al., 2020). With the increase in mathematical creativity, the mathematical ability of students also increases. The opinions above illustrate that the success of learning mathematics can be correlated with the creativity of thinking students.

Research on the correlation of thinking creativity with mathematics learning success has been widely conducted. In general, researchers found that creative thinking has a significant relationship with mathematics learning outcomes (Eva & Kusrini, 2015; Inuusah et al., 2019). However, some find different research results, for example previous study concludes that the correlation of thinking creativity with learning outcomes is not significant. Inconsistencies in research findings are natural but can affect scientific treasures (Agustina & Noor, 2016). Therefore, efforts are needed to evaluate the results of these studies that can provide the right conclusions. One way that can be taken is to conduct this meta-analysis that simultaneously examines the results of primary research. A meta-analysis of the correlation of thinking creativity with mathematics learning outcomes has been conducted by previous study however, the sample used did not involve the results of primary studies in Indonesia (Bicer et al., 2021). Therefore, this meta-analysis research is very important. This study aims analyze the correlation of thinking creativity with the success of learning mathematics simultaneously from the results of primary studies in the territory of the Unitary State of the Republic of Indonesia.

2. METHODS

This research is a quantitative study that uses meta-analysis studies (Bicer et al., 2021). This meta-analysis was conducted on the results of primary research on the correlation of thinking creativity with mathematics learning outcomes published through online journal institutions in the last 10 years. The research data collection implemented a virtual search system using the Publish or Perish search engine. Data search using keywords correlation, relationship, creativity, mathematics learning outcomes, and mathematics learning achievement, number of samples submitted in search engines use the default reference of 200 articles. The publication data generated by the Publish or Perish Application Program is further examined based on inclusion criteria. Furthermore, data extraction is carried out on publications that meet the criteria. Articles that report more than one correlation between creativity and math learning outcomes are categorized as more than one publication. The publication data is then extracted and further analyzed. The research procedure is show in Figure 1.

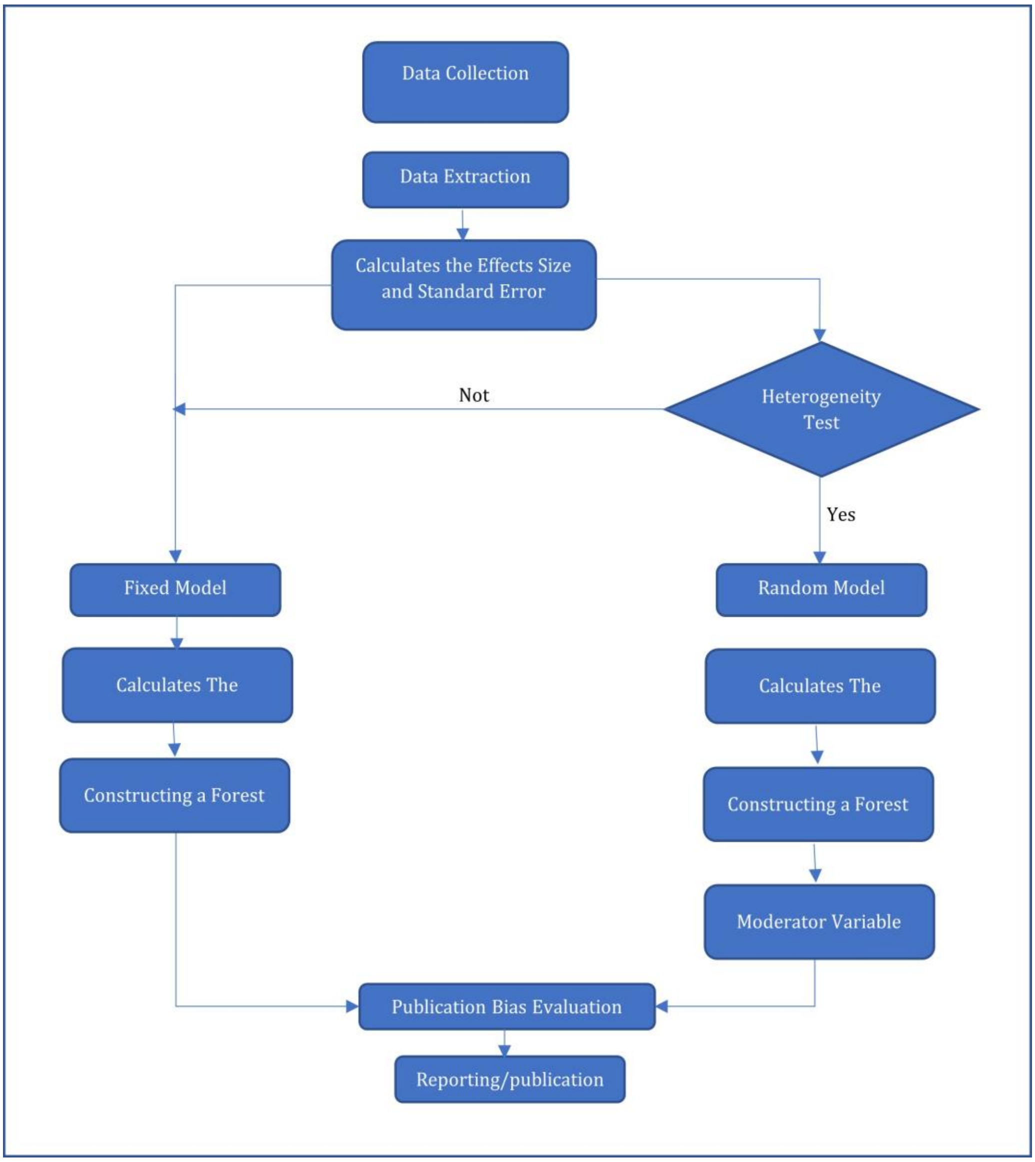

Figure 1. Research Procedure

Technically, the data analysis of this study used Microsoft Excel Computer Application Program and JASP. The Microsoft Excel program is used to calculate the effect size and standard error of each study and the calculation of moderator variables. The JASP program is used to calculate variance in effect size, aggregate effect size, and potential publication bias. Testing the significance of variance, aggregates, and potential bias using a 95% confidence interval. The results of the effect size analysis are classified base on criteria listed in Table 1.

Table 1. Effect Size Category

No	Effect Size	Category
1	≤ 0.2	Poor
2	$0.2 < z \leq 0.5$	Moderate
3	$0.5 < z \leq 1$	Strong
4	$1 < z$	Very Strong

Evaluation of potential publication bias was conducted using Kendall's Rank Correlation Test for the Plot Asymmetry method. This method uses the hypothesis that funnel plots are not symmetrical (there are indications that it could be published). The publication is said to be bias-free (symmetric funnel plot) if Kendall's Rank Correlation has a p-value > 0.05 (Retnawati et al., 2018). Graphically, the procedure of this study is presented in figure 1 above.

3. RESULTS AND DISCUSSION

Results

The results of a search of 200 articles produced by the Publish or Perish application program, obtained 14 primary studies that fit the specified criteria. The fourteen studies consisted of 2 research studies at the elementary school (ES) level, 7 studies at the junior high school (JHS) level, 3 studies at the senior high school and vocational (SHS) levels, and 2 studies at the higher education (HE) level. Data extraction of study data using sample size data (n), school level, and correlation coefficient (r). The data extraction results of 14 studies that met the criteria are presented in Table 2.

Table 2. Data Extraction Results

No	Author (Year)	School Level	Sample	Correlation
1	(Agustina & Noor, 2016)	JHS	33	-0.033
2	(Agustina & Noor, 2016)	JHS	33	-0.054
3	(Palupi & Septiana, 2018)	SHS	49	0.372
4	(Khofifah et al., 2023)	ES	15	0.878
5	(Jehadus et al., 2019)	SHS	68	0.413
6	(Juwita et al., 2020)	JHS	32	0.671
7	(Laruli, 2019)	JHS	60	0.654
8	(Manurung et al., 2020)	ES	36	0.409
9	(Eva & Kusrini, 2015)	JHS	60	0.982
10	(Mualifah et al., 2020)	JHS	60	0.348
11	(Nisrina et al., 2018)	SHS	40	0.504
12	(Permatasari et al., 2018)	HE	25	0.776
13	(Wahyuddin, 2016)	SHS	75	0.487
14	(Wahyuni & Kurniawan, 2018)	HE	11	0.475

The effect size correlates the variable of thinking creativity with the variable of mathematical learning success is the aggregate effect size of all primary studies. The aggregate was derived from the effect size of each study and its standard error. The effect size of each study has been calculated based on the value of the correlation coefficient (r), while the standard error (SE) is calculated based on the sample size (n). The effect size of each study was expressed by z. Data on effect size and standard error for each study can be seen in Table 3.

Table 3. Effect Size and Standard Error for Each Study

No	Author (Year)	n	R	Z	Category	SE
1	Agustina et al. (2016)	33	-0.033	-0.033	Poor	0.183
2	Agustina et al. (2016)	33	-0.054	-0.054	Poor	0.183
3	Bicer et al., (2021)	49	0.372	0.391	Moderate	0.147
4	Khofifah et al. (2023)	15	0.878	1.367	Very Strong	0.289

No	Author (Year)	n	R	Z	Category	SE
5	Eva et al. (2015)	60	0.982	2.351	Very Strong	0.132
6	Jehadus et al. (2019)	68	0.413	0.439	Moderate	0.124
7	Juwita et al. (2020)	32	0.671	0.813	Strong	0.186
8	Laruli (2019)	60	0.654	0.782	Strong	0.132
9	Manurung et al. (2020)	36	0.409	0.434	Moderate	0.174
10	Mualifah et al (2020)	60	0.348	0.363	Moderate	0.132
11	Nisrina et al. (2021)	40	0.504	0.555	Strong	0.164
12	Permatasari (2018)	25	0.776	1.035	Very Strong	0.213
13	Wahyudin (2016)	75	0.487	0.532	Moderate	0.118
14	Wahyuni et al. (2018)	11	0.475	0.517	Moderate	0.354

The effect size of each study varied widely as shown by Table 3. The lowest effect size was z = -0.054 obtained from the transformation result r = -0.054, while the largest effect size was z = 2.351 obtained from the transformation result r = 0.982. Based on Cohen's (Cohen, 1988), effect sizes are grouped into 4 (four) categories, namely weak, medium, strong, and very strong. There were 2 (two) studies 14.29% were in the weak effect size category, 6 (six) studies or 42.86% were in the medium effect size category, 3 (three) studies or 21.43% were in the strong effect size category, and there were 3 (three) studies or 21.43% were in the very strong effect size category. Thus, the effect size of the studies included was dominated by studies with moderate effect size

Variance Heterogeneity Testing and Aggregate Effect Size

The JASP Computer Application Program has provided test results against heterogeneity of variance and aggregate effect sizes. The heterogeneity of effect variances and their aggregates were analyzed by using the Fixed-Model. Based on testing using the Fixed Model at a 95% confidence level, an aggregate of effect size (Z) = 0.691 with a p-value of < 0.001 was obtained. The aggregate size of these effects is in the strong category (Cohen, 1998), and significant because it has a p-value of less than 0.05. Data on the results of estimating heterogeneity and aggregate effect size can be seen in Table 4.

Table 4. Heterogeneity of Variance and Aggregate Size Effects

Model	K	Z	95%-CI	P	Df	Heterogeneity	
						Q	P
Fixed	14	0.691	1.380 - 1.601	<0.001	13	217.709	<0.001
Random	14	0.676	0.357 - 0.994	<0.001	13		

Base on Table 4, the results of heterogeneity testing using the Fixed Model obtained a Q value of 217.709 with p < 0.001. The achievement of the p-value indicates that the variance in the effect size is not homogeneous, or in other words, the variance is in heterogeneous conditions. This indicates that the use of the Fixes Model to analyze the aggregate of effect sizes is not appropriate which allows the emergence of estimated results that have low precision so that they have the potential to draw inappropriate conclusions To obtain the right conclusion, the aggregate of effect sizes need to analyses by using a Random-Model with the same level of confidence. After testing using the Random Model, an aggregate of effect size (Z) = 0.676 was obtained. The aggregate effect size of the analysis results using a randomized model was 2.17% smaller compared to the aggregate of test results using the Fixed Model. In detail, the diversity of effect sizes as referred to above can be seen in the Forest Plot output of JASP in Figure 2.

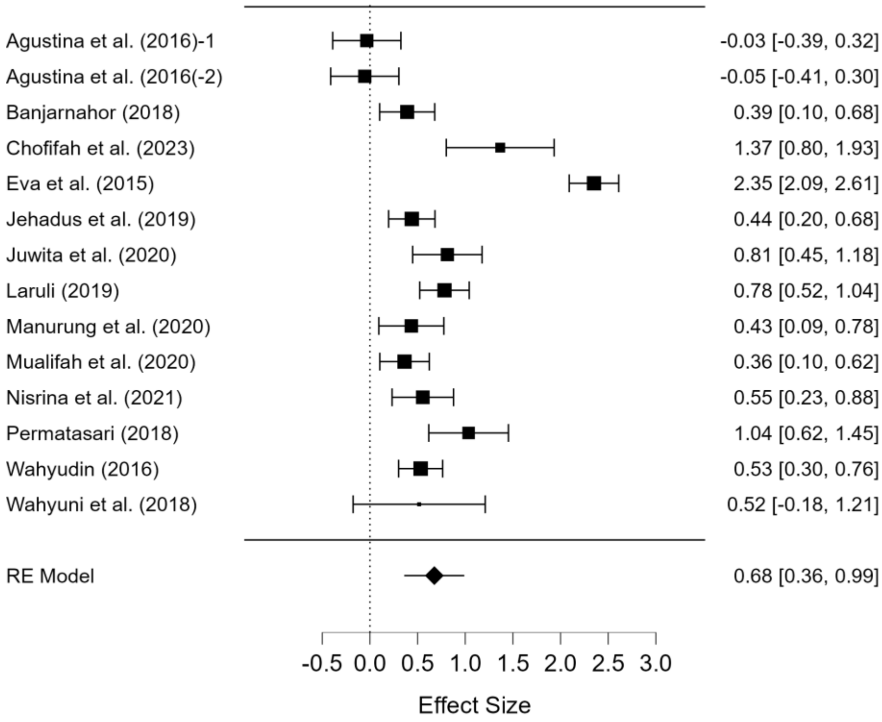

Figure 2. Forest Plot Effect Size

Figure 2 shows that each study had an effect size located at varying intervals. There were 3 (three) studies that had effect sizes in the range containing zero points, namely at interval intervals [-0.39; 0.32], [-0.41; 0.30], and [-0.18; 1.21]. The three studies had different effect sizes, namely 2 studies had effect sizes in the weak category and one study was in the strong category. The belief interval containing the zero point indicates that statistically these studies have an insignificant size effect (Retnawati et al., 2018). In Figure 2 it appears that the result of the aggregation of effect sizes is at a confidence interval [0.36; 0.00] with the value Z = 0.68. The aggregate value is in the category of strong and significant effect size at a confidence level of 95%. Furthermore, based on the value of z and the confidence interval Z, it is transformed into a coefficient r*. The result of the transformation obtained a coefficient r* of 0.589 with an interval [0.343; 0.759]. Referring to Cohen (Cohen, 1988), the value of r* indicates that the correlation of thinking creativity with mathematics learning success is in a strong category.

Moderator Variables Analysis

The significance of the variance in effect size of studies provides an opportunity to explore potential differences in effect size variance in certain variables. The variables that might be explored are variables such as publication time, many samples, and education levels. Tracking potential differences is done using a Random Model. The results of the search for these moderator variables can be seen in Table 5.

Table 5. Heterogeneity of Variance and Aggregate Effect Size on Moderator Variables

Variable	N	Z	P	Heterogeneity				
				Q	Df	Qw	Qb	p (χ^2)
Year of Publication								
2015-2019	9	0.668	0.005	201.746	1	214.128	3.581	0.058
2020-2024	5	0.664	<0.001	12.382				

Variable	N	Z	P	Heterogeneity				
				Q	Df	Qw	Qb	p (χ^2)
Sample Size								
Small	9	0.536	<0.001	36.525	1	196.856	20.853	<0.001
Large	5	0.893	0.016	160.331				
School-Level								
ES	2	0.872	0.061	7.653	3	205.495	12.214	0.007
JHS	7	0.683	0.027	195.690				
SHS	3	0,453	<0.001	0.573				
HE	2	0.853	<0.001	1.579				

In Table 5, it appears that publications in the period 2015-2019 obtained an aggregate securities size of 0.668 with p-value = 0.005. The aggregate size of securities in the period 2020-2024 has almost the same value of 0.664 with a p-value of < 0.001. Both aggregates are in the strong and significant category at a 95% confidence level. The results of the analysis of the variance of the effect size on the Variable Year of Publication obtained variance Qb = 3.581 with p-value (χ^2) = 0.058. The results of this analysis show that $p > \alpha = 0.05$ which indicates that Qb is homogeneous or not significantly heterogeneous. The results of this test are supported by the difference in aggregate effect size between times which only has a difference of 0.004. This means that the difference in publication time has no impact on the variance in the size of the correlation effect.

The sample from each primary study analyzed in this study was of varying size. As a moderator variable, the sample size is divided into 2 (two) groups. Studies that have n less than 50 are grouped in the small sample category, while studies that have n at least 50 are categorized as studies with large samples. In Table 5 it appears that studies on small sample sizes have an aggregate effect size of 0.536 with a p-value < 0.001 and studies with large sample sizes have an aggregate effect size of 0.893 with a p-value = 0.016. Both aggregates are in the strong category. The results of the analysis of the effect size obtained a Qb value = 20.853 with a p-value of < 0.001. The results of the variance analysis indicate that the effect size variance is significantly different because it has a p-value of less than 0.05. This difference was also seen in the aggregate difference in effect size in studies that had a large sample with a small sample that reached 35.7%. Thus, it can be said that the difference in sample size has an impact on the difference in the correlation effect of the two variables.

School-level variables from the studies analyzed in this study are grouped into 4 (four) categories, namely elementary, junior high, senior high school, and college. In table 5 it can be seen that the aggregate effect size of each level is not in the same category. At the elementary school level, an aggregate (Z_{ES}) = 0.872 was obtained which was in the strong category with a p-value = 0.061. At the junior high school level, an aggregate (Z_{JHS}) = 0.683 was obtained with p-value = 0.027. The aggregate at the junior high school level is smaller than the aggregate at the elementary school level. At the SHS level, an aggregate (Z_{SHS}) = 0.453 was obtained which was in the medium effect size category, with a p-value of < 0.001. The aggregate size of the effect at the SHS level is smaller than the aggregate size of the effect at the previous level. At the college level, the aggregate (Z_{HE}) is almost the same as the aggregate in elementary school, which is 0.853 with a p-value of < 0.001. The results of the analysis of variance in the size of the aggregate effect obtained a Qb value = 12.214 with p-value = 0.007. At the 95% confidence level, the p-value showed that the four measures of effect on education differed significantly.

Evaluation of Publication Bias

Publication bias testing in this study used Kendall's Rank Correlation Test for the Plot Asymmetry indicator. The test results can be seen in Table 6.

Table 6. Rank Correlation Test for Plot Asyimetry

Criteria	Kendall's T	Number of Studies (k)	P
Rank Test	0.146	14	0.474

Based on Table 6, it appears that the correlation between the size of the effect and the variance of the effect size obtained Kendall's T coefficient of 0.146 with p-value = 0.474. The probability of Kendall's T having a value greater than 0.05 indicates that the funnel plot is symmetrical. This means that the primary studies analyzed in this study found no indication of publication bias. Therefore, at a confidence level of 95% the conclusions generated from this study, can be trusted.

Discussion

Education is needed by everyone to maintain their existence and improve their quality of life. Human dignity and dignity are expected to be raised through a good education process. The results of a person's education can be seen in how he does, does, speaks, and behaves. Creativity in thinking is one of the potentials that must be developed through education. Creativity thinking in mathematics is needed. Many math problems are difficult to solve without creative thinking. Often a problem requires the use of various concepts or procedures and even non-procedural ways to solve it. The ability to synthesize or think about and produce ways of solving affects success in learning mathematics. This meta-analysis analysis analyzed the correlation of thinking creativity with mathematics learning success that has been published in the last 10 years. The results of the analysis based on extracted data indicate that the overall correlation between thinking creativity and mathematics learning success has a strong effect size (Z = 0.676) and is significant at a 95% confidence level with a p-value < 0.01. The result of the effect size transformation resulted in a correlation coefficient that was in the strong category, namely r = 0.589 at 95%-CI [0.343; 0.759]. The findings of this study are still consistent with the results of the study (Eva & Kusrini, 2015; Khofifah et al., 2023). Nonetheless, the study's findings have revealed a correlation strength that is somewhat different from the findings of Bicer et al's study. Previous study conclude that the correlation of thinking creativity with learning achievement is in the medium category (Bicer et al., 2021). The difference in findings can be caused by the correlation coefficient and the location of the research from the study samples analyzed.

Based on the results of data analysis, it has been conclusively obtained that the effect size of primary studies has significant variance so this meta-analysis study conducts further analysis of moderator variables, both time variables, sample size, and education level. The results of further analysis found that the results of research published before the Covid-19 pandemic (2015-2019) and during the Covid-19 pandemic until after (2020-2024) found no indication of a significant difference in the correlation of thinking creativity with mathematics learning success. The results of the analysis of sample size variables have resulted in findings that sample size has a significant effect on the size of the correlation effect. This means that, the larger the sample size, the greater the size of the correlation effect between creative thinking and math learning success (Al-Ahdal & Abduh, 2021; Hill, 2021). Conversely, the smaller the sample size, the smaller the effect size, and the correlation of thinking creativity with math learning success.

The results of the analysis of education level variables have revealed the correlation of creative thinking skills with the success of learning mathematics at all levels of education, both at the elementary school, middle school, and college levels. The results of data analysis showed that at all levels of education, the size of the correlation effect of the two variables was at least in the medium category. The highest correlation was found at the elementary school level followed by the higher education level. Although the results of the research. concluded that the correlation of thinking creativity with mathematics learning outcomes is not significant, the results of this meta-analysis study have refuted this because the size of the correlation effect at the junior high school level was found to be significant (Agustina & Noor, 2016). Meanwhile, at the high school level, the correlation was found to be in the medium category. This shows that the level of education is not directly proportional to the correlation between creativity and success in learning mathematics. The findings of this study support the opinion who explain that everyone has creative thinking skills but children have more because they have not fully understood rigid and convergent logic (Kampylis & Berki, 2014).

The findings of this meta-analysis study illustrate that creative thinking skills are very important to be considered and developed at all levels of education. In learning something, creativity is the initial capital for students. Creative learners usually easily solve a problems (Kattou et al., 2013; Tahir & Marniati, 2018). If they can think flexibly, fluently, broad-mindedly, and originally, they will be able to use mathematical processes and knowledge according to the situation of the task or problem being solved. The development of creative thinking skills can be done using various methods, models or learning approaches both individual and collaborative, In learning, the development of creative thinking skills should not only be individual but can also be collaborative. Collaboration develops creative thinking skills, allowing students or communities to consider various perspectives together (Kampylis & Berki, 2014; Nurlaela et al., 2018). Collaborative learning in the form of study groups can have a significant impact on students' thinking creativity and mathematics learning outcomes. In learning groups, students can inspire each other and share experiences in finding various ideas, alternative procedures, and alternative solutions to a problem. The creativity of thinking in mathematics is supported by individual experience (Arifin & Retnawati, 2017; Tyagi, 2016). The experience can be had by students through supportive learning. Learning mathematics needs to be done with an emphasis on problem-solving. Through problem-solving activities, students have the opportunity to explore problems and generate various creative ideas both procedures and alternative solutions.

This research has implications for efforts to improve mathematics learning by emphasizing the development of students' thinking creativity. This study only examines the results of research in Indonesia so the conclusions are still limited. Therefore, future research needs to conduct a meta-analysis that compares the correlation of thinking creativity with mathematics learning success between countries.

4. CONCLUSION

Based on the discussion of the results of the research above, it can be concluded that creative thinking has a strong correlation with the success of learning mathematics. Thus, the more creative students are, the potential for success in learning mathematics is higher, on the contrary, the lower the creativity of thinking students, the potential for success in learning mathematics is also lower. Other conclusions from this study are (1) there is a significant difference in the size of the effect of the correlation of thinking creativity with mathematics success between levels of education and between small size samples and large samples, and (2) there is no significant difference in the size of the effect of correlation of thinking creativity with mathematics learning success based on the year of publication.

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