American Journal of Educational Research, 2021, Vol. 9, No. 5, 286-290
Available online at http://pubs.sciepub.com/education/9/5/6
Published by Science and Education Publishing
DOI:10.12691/education-9-5-6

Meta-analysis of the Effect of Different Learning Models on Student's Mathematic Critical Thinking Ability

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Received April 02, 2021; Revised May 05, 2021; Accepted May 14, 2021

Abstract This research aims to: Analyzing the effect size of different learning models on mathematical critical thinking abilities. This type of research is a meta-analysis research with a sample size of 8 journals indexed in Sinta RistekDikti and filtered through coding. The results showed that: Of the eight studies that met the criteria for a meta-analysis of different mathematics learning models in improving junior high school students' mathematical critical thinking abilities, the highest effect size with a value of 0,8247 was a problem-based learning model. So that the model is considered more effective in improving the mathematical critical thinking abilities of junior high school students. The results of the analysis with the random effect model show that there is a significant positive correlation between the learning model and the students' mathematical critical thinking abilities ($z = 5{,}785 < 0{,}001$; 95% CI [0.480; 0.971]) with the mean effect size of the effect of the learning model on mathematical critical thinking abilities, included in the large category with $r_{RE} = 0.725$.

Keywords: *meta-analysis, critical thinking abilities, effect size*

Cite This Article: Erni Susanti, E. Elvis Napitupulu, and Hasratuddin, "Meta-analysis of the Effect of Different Learning Models on Student's Mathematic Critical Thinking Ability." *American Journal of Educational Research*, vol. 9, no. 5 (2021): 286-290. doi: 10.12691/education-9-5-6.

1. Introduction

Education is a very important aspect for the life of a nation. Through effective education the civilization of a nation is built. An educated society is expected to be able to compete with countries in a world full of competition. Competition in the future will certainly grow in the framework of the rapid development of one's knowledge. This is in line with Dumciuvience (2015) which states that in terms of future growth a country depends on knowledge.

One of the compulsory subjects in formal education which has a very important position and role is mathematics. The role of mathematics in life can be very easy to find, starting from very simple things such as buying and selling, money as a means of transacting and socializing in life. In the world of education mathematics also supports other sciences such as physics, biology and so on. So that mathematics is mentioned by many scholars as the queen of all sciences. Rahayu & Kusuma (2019) illustrate that the importance of mathematics is inseparable from its role in all types of life dimensions as previously described.

Based on the results of the 2018 Program for International Student Assessment (PISA), students' math abilities in Indonesia are at the 72 level out of 78 participating countries with a score of 379 points. This shows that students in Indonesia are not familiar with international standard questions that require deep mathematical critical thinking abilities.

The ability to think critically in mathematics is one of the goals as well as an indication of success in learning mathematics. Glasser (in Fisher, 2009: 3) defines that critical thinking requires hard efforts to examine every belief or assumptive knowledge based on supporting evidence and the following conclusions that result [1]. In line with this, Eggen (2012: 119) says that critical thinking is the ability and tendency to make and assess conclusions based on evidence [2]. Fahruddin Faiz (2015: 2) argues that the goal of critical thinking is simple, namely to ensure, as far as possible, that our thinking is valid and correct [3]. Someone is said to have the ability to think critically if they meet certain indicators.

The indicators of mathematical critical thinking according to Facione (2011) are: interpretation, analysis, evaluation, inference, explanation and regulation. Interpretation enables students to understand and express and describe a problem (Facione, 2015: 5) [4]. The analysis reflects that students are able to identify the relationship between various statements, questions, concepts and descriptions. Furthermore, evaluation shows students are able to assess the credibility of a statement and the truth of a relationship between question statements, concepts and descriptions and others. As for the inference indicator, students are required to be able to provide conclusions or provide reasons for the steps taken. Explanation is the ability to explain or state the results of

thoughts based on evidence, methodology, and context. Furthermore, self regulation is the ability to regulate the way of thinking. Mathematical critical thinking abilities are very important abilities (Junaidi, 2017; Liberna, 2015; Jumaisyaroh et al, 2014; Istianah, 2013) [5,6,7,8]. It was also revealed by Sumaryati (2013) that mastering mathematical critical thinking abilities is important because it is needed to welcome a changing future [9]. This is in line with Istianah (2013) which states that by mastering mathematical critical thinking abilities, students are expected to be able to solve problems in a world that changes continuously [8].

So, mathematical critical thinking abilities have an important role for students in welcoming a dynamic future. This makes students need the best alternative choices in solving a problem. Students need mathematical critical thinking abilities when faced with challenges by considering the information received, making plans, determining decisions taken, making decisions, and evaluating (Syarif, 2017) [10].

Based on the number of similar studies, it will certainly raise questions from the minds of the people who use these studies. What's more, the research results provide different conclusions. Jumaisyaroh et al (2014) stated that students' mathematical critical thinking abilities were improved with a problem-based learning model compared to being given direct learning [7]. Abdurahim (2016) concluded that realistic learning models are more effective than conventional learning in improving students' mathematical critical thinking abilities. Meanwhile, Kusumadewi et al (2013) explained that the learning model of Contextual Teaching and Learning assisted by Macromedia Flash 8 can be used as an innovation in learning mathematics which is effective in improving students' mathematical critical thinking abilities. As well as many other studies that give different conclusions.

Little et al (2008) stated that meta-analysis technique is a statistical method to combine quantitative results from several experimental studies to produce an overall summary of empirical knowledge on a particular topic [11]. It is used to analyze central trends and variations in study results. In this study, researchers will use several samples in the form of previous research with similar topics to obtain information and can be analyzed further.

Based on the problems that have been described and the studies that have been carried out, researchers have conducted research related to the meta-analysis of the effects of various learning models on students' mathematical critical thinking abilities.

2. Methods

2.1. Research Pattern

This type of research is a meta-analysis research, which is a form of quantitative research that uses numbers and statistical methods from several experimental research results to organize and extract as much information as possible from the data obtained, so that it approaches comprehensiveness and finds the effect size. The research method used is descriptive research, namely the analysis of presenting the results of scientific research publications on electronic journals nationally related to the effect of various learning models on students' mathematical critical thinking abilities.

2.2. Subject

The subjects in this study are the results of research from scientific publication articles in the form of national-scale journals in Indonesia regarding the use of various learning models in 2011-2020.

2.3. Instruments

The instrument used in this study was the coding data sheet. Identification of the search and retrieval process of coding according to the criteria that meet the requirements explicitly, checking each study against the appropriate criteria and recording the information on the screening form or database are important notes in the scientific publication of the research synthesis.

2.4. Data Analysis

The data analysis techniques used in this study are:

1) Calculating the effect size and standard error

The Effect Size formula used is the eta square (η2) formula. Kadir (2017: 300) states that experimental research involving only two control groups [12], namely the experimental group and the control group uses comparative analysis with t-test analysis techniques, then uses the effect size formula as follows:

$$\eta^2 = r^2 = \frac{t_0^2}{t_0^2 + db}$$

For experimental research involving more than two groups using comparative analysis with the Anova-1 Way analysis technique with the following formula:

$$\eta^2 = \frac{JK_{antara}}{JK_{total}}$$

For experimental research involving more than two groups and their interactions, using comparative analysis with the Anova-2 road analysis technique, so the formula used is:

$$\eta_A^2 = \frac{JK(A)}{JK(A) + JK(D)}$$

$$\eta_B^2 = \frac{JK(B)}{JK(B) + JK(D)}$$

$$\eta_{AB}^2 = \frac{JK(AB)}{JK(AB) + JK(D)}$$

Experimental research with the assumption of a heterogeneous group of two formula groups used (Glass, 2012) [13]:

$$\Delta = d = \frac{\bar{x}_E - \bar{x}_K}{s_K}$$

For correlation (r) then transformed using z fisher and perform summary meta-analysis with this index.

Retnawati et al (2018: 29) [14] say to transform r to z fisher the following equation is used:

$$Z = 0,5 \times \ln\left(\frac{1+r}{1-r}\right)$$

The variance of z and the standard error, namely:

$$V_Z = \frac{1}{n-3}, SE_Z = \sqrt{V_Z}$$

After d is known, it is converted from d to r. To change the standardized mean difference (d) to correlation (r) use the following equation:

$$r = \frac{d}{\sqrt{d^2 + a}}$$

Where a is the correction factor for the case $n_1 \neq n_2$ i.e.:

$$a = \frac{(n_1 - n_2)^2}{n_1 n_2}$$

While in the case of $n_1 = n_2$, $a = 4$ is used. While the variance for r is:

$$V_r = \frac{a^2 V_d}{\left(d^2 + a\right)^3}$$

The criteria used in forming the interpretation of the results of the correlation effect size use references from Cohen (1997), namely:

Small effect: $r \leq 0,10$

Medium effect: $r = 0,25$

Great effect: $r \geq 0,40$

2) Heterogenity, *Summary Effect* and bias correction with *software JASP*

3. Results and Discussion

a) Data on Effect Size Results of Variety of Learning Models based on Categories in the Improvement of Junior High School Students' Mathematical Critical Thinking Ability

The following is the effect size data that has been categorized as shown in Table 1.

Table 1. Effect Size Result Data Based on Influence Category (effect size)

No	Code	*Effect Size (r)*	Category
1	04Q	0,7826	Great
2	05Q	0,8247	Great
3	12Q	0,289	Medium
4	16Q	0,7218	Great
5	17Q	0,3660	Meduim
6	19Q (1)	0,5442	Great
7	19Q(2)	0,3469	Medium
8	24Q	0,7622	Great

The results of the analysis data in Table 1. show that there are five scientific publication articles with a large effect size price, three scientific publication articles with a moderate effect size price.

b) Data Effect Size Variety of Learning Models Based on Research-Free Variables in Improving Junior High School Students' Mathematical Thinking Ability

The following is the effect size data based on the independent variables of research in pursuing the mathematical critical thinking abilities of junior high school students presented in Table 2.

Table 2. Effect Size Data Based on Research Variables

NO	Research Independent Variables	*Effect Size(r)*
1	Missouri Mathematic Project (MMP) Learning Model Using Think Talk Write (TTW) Strategy	0, 7826
2	Problem Based Learning	0,8247
3	Portfolio-Based Group Investigation and Guided Discovery Learning	0, 2893
4	Realistic Mathematical Approach	0,7218
5	Problem Based Learning with Cognitive Conflict strategies	0,3660
6	Problem Based Learning and Problem Possing	0, 5442
7	Conventional Learning	0, 3469
8	PBL Collaborative Setting	0,7622

Table 2 shows that of the various approaches and learning models applied in student classes, the one that has the most impact on the progress of increasing students' mathematical critical thinking abilities is problem-based learning with an effect size value of 0,8247. This is followed by the learning model. Missouri Mathematic Project (MMP) uses the Think Talk Write (TTW) strategy with an effect size of 0,7826.

c) Data from Classical Metaanalysis Results of Variety of Learning Models in Improving Junior High School Students' Mathematical Thinking Ability by Using JASP software

1) Heterogenity

Fixed and Random Effects						
	Q		**df**		**p**	
Omnibus test of Model Coefficients	33.466		1		< .001	
Test of Residual Heterogeneity	59.627		7		< .001	
Note. p -values are approximate.						

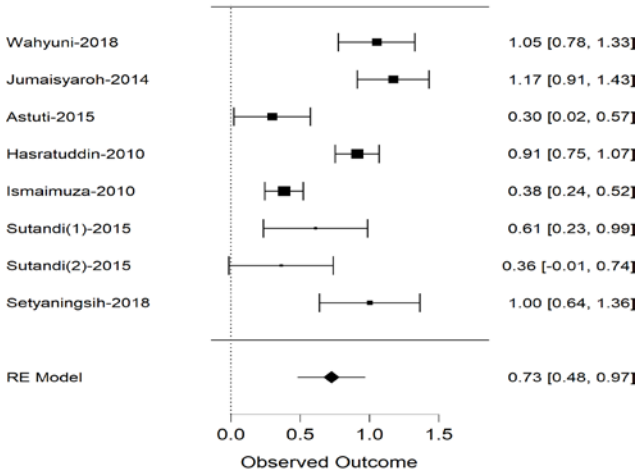
The analysis showed that the effect sizes of the 8 studies analyzed were heterogeneous (Q = 59,267; p <0,001). Thus, the appropriate model to use is the random effect size model to estimate the average effect size of the eight studies that have met the criteria to be investigated by meta-analysis. The results of the analysis also indicate that there is potential to investigate the moderator variable which of course affects students' mathematical critical thinking abilities.

2) *Summary effect/ Mean Effect Size*

Coefficients						
					95% Confidence Interval	
	Estimate	**Standard Error**	**z**	**p**	**Lower**	**Upper**
intercept	0.725	0.125	5.785	< .001	0.480	0.971
Note. Wald test.						

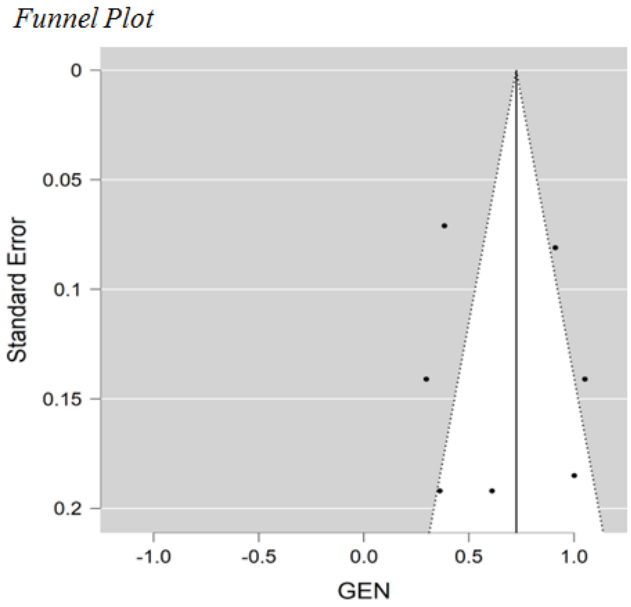
The results of the analysis using the random effect model showed that there was a significant positive correlation between the learning model and the students' mathematical critical thinking abilities (z = 5,785 <0,001; 95% CI [0,480; 0,971]). The mean effect size of the effect of the learning model on mathematical critical thinking abilities is included in the large category with r_{RE}= 0,725.

3) *Forest Plot*



From the forest plot, it can be observed that the effect size of the studies analyzed varies, ranging from 0,30 to 1,17.

4) Publication Bias Evaluation



The results of the Fuunel plot are difficult to conclude whether the funnel plot is symmetrical or not, so an egger's test is needed to test whether the funnel plot is symmetrical or not.

Regression test for Funnel plot asymmetry ("Egger's test")		
	z	**p**
sei	-0.011	0.991

Based on the data, it shows P > 0,05 which confirms that the funnel plot is symmetrical. Thus it can be concluded that there is no problem of publication bias in the meta-analysis studies conducted.

5) *Fail-Safe N*

File Drawer Analysis			
	Fail-safe N	**Target Significance**	**Observed Significance**
Rosenthal	760.000	0.050	< .001

Based on Rosenthal's assumption in the Fail-Save N method because K = 8 so that 5k + 10 = 5 (8) +10 = 50. The Fail Save-N value obtained is 760,000. With a significant target of 0,005 and p < 0,001. Since the Fail save-N value is > 5k + 10, it can be concluded that there is no publication bias in the meta-analysis studies conducted.

4. Conclusions

1. Of the eight studies that met the criteria for a meta-analysis of various mathematics learning models in improving junior high school students' mathematical critical thinking abilities, research conducted by T. Jumaisyaroh, E. E Napitupulu and Hasratuddin in 2014 with a model with problem-based learning is a model that has an effect the highest size with a value of 0,8247 among other learning models. This means that the problem-based learning model is considered more effective in improving the mathematical critical thinking abilities of junior high school students.
2. Based on the results of the meta-analysis that has been done, it is found that with the random effect model there is a significant positive correlation between the learning model and the students' mathematical critical thinking abilities (z = 5,785 <0,001; 95% CI [0,480; 0,971]). The effect of the learning model on mathematical critical thinking abilities is included in the great category with r_{RE} = 0,725.

References

[1] Fisher, Alec. (2008). *Berpikir Kritis Matematis: Sebuah Pengantar*. Jakarata: Erlangga.

[2] Eggen, P., & Kauchak, D. (2012). *Strategi dan model pembelajaran: Mengajarkan Konten dan Kemampuan Berpikir*. Jakarta: PT. Indeks.

[3] Faiz, F. (2012). *Thinking Skill: Pengantar Menuju Berpikir Kritis.* Yogyakarta: Suka Press.

[4] Facione, P. A. (2011). *Critical Thingking: What it is and why it Counts.* Think- Critically, Pearson Education.

[5] Facione, P. A. (2011). *Critical Thingking: What it is and why it Counts.* Think- Critically, Pearson Education.

[6] Liberna, H. (2015). Peningkatan Kemampuan Berpikir Kritis Matematis Siswa Melalui Penggunaan Metode Improve Pada Materi Sistem Persamaan Linear Dua Variabel. *Formatif: Jurnal Ilmiah Pendidikan MIPA*, 2(3), 190-197.

[7] Jumaisyaraoh, T., Napitupulu, E. E., & Hasratuddin. (2015). Penigkatan Kemampuan Berpikir Kritis Matematis dan Kemandirian Belajar Siswa SMP Melalui Pembelajaran Berbasis Masalah. *Kreano, Jurnal Matematika Kreatif dan Inofatif* 5(1), 87-106.

[8] Istianah, E. (2013). Meningkatkan Kemampuan Berpikir Kritis Matematis dan Kreatif Matematik Dengan Pendekatan Model Eliciting Activities (MEAs) Pada Siswa SMA. *Infinity Journal*, 2(1), 43-54.

[9] Setyawati, R. D. (2013). Pengembangan Perangkat Pembelajaran Matematika Model Problem Based Learning Berorientasi Enterpreneurship dan Berbantuan CD Interaktif. *Prosiding*

Seminar Nasional Matematika Semarang: Universitas Negeri Semarang.

[10] Syarif, M. (2017). Pembelajaran Dengan PendekatanProblem Solving Untuk Meningkatkan Kemampuan Berpikir Kritis Kritis dan Kreatif Matematika Siswa SMA. *Jurnal Mutiara Pedagogik*, 1(2), 92-101.

[11] Littel, J. H., Pillai, V. K., & Corcoran, J. (2008). *Systematic Review and Meta Analysis*. United State of America: Oxford University Press, p. 1-2.

[12] Kadir. (2017). *Meta-Analysis of the Effect of Learning Intervention toward Mathematical*. Society.4 (2), pp. 165.

[13] Glass, G. (2012). Meta-Analysis of Research on Class Size and Achievment. *Jstore*. Vol.1. No. 1.

[14] Retnawati, H, dkk. 2018. Pengantar Analisis Meta. Parama Publishing : Yogyakarta.