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Relationship between cooperative learning method and students' mathematics learning achievement: A meta-analysis correlation

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Abstract

An appropriate learning method can improve students' learning achievement. The cooperative learning method encourages students to improve their mathematics learning achievement. Mathematics learning achievement is one indicator of achieving learning objectives. Mathematics is an important lesson to be learned and must be mastered by students. The purpose of this research was to analyze the effect size of the relationship between Cooperative learning method and mathematics learning achievement through meta-analysis quantitative research approach. In this research, the cooperative learning method serves as an independent variable, and mathematics learning achievement serves as the dependent variable. The data was obtained from the online database search results on Google Scholar in 2010-2020. The sample used was 16 research publications that have met the specified criteria. The data analysis technique used was the meta-analysis quantitative approach with correlation meta-analysis. The results showed that there was a positive and significant relationship (level of 5%) between the cooperative learning method and students' mathematics learning achievement. The average effect size value was 0.15 in the range of 0.04 to 0.27 which was included in the low category. These results have proven the consistency of the findings of previous research.

INTRODUCTION

It is important to learn mathematics in daily life because it is directly related to technological development (Mutlu, 2019). Mathematics is a knowledge gained from the learning process (Gie, 1993). Repetition in learning mathematics will form a meaningful formation of mathematical knowledge as well as forming interactions between students and materials learned with daily life since the learning theories are both constructivism and behaviorism (Cobb et al, 1992; Lerman, 1996; Zevenbergen, 1996). Mathematics in the curriculum must be taught since basic education (Kemendikbud, 2013). Learning mathematics is still considered difficult by most students from basic education to higher education in terms of interpreting mathematical symbols, mathematical concepts, and procedures (Silver, 1986; Hiebert & Lefevre, 1986; Lampert, 1986; Wearne & Hiebert, 1988; Research Council, 1989; Byrnes & Wasik, 1991; Hiebert & Carpenter, 1992; Janvier et al, 1993; Ben-Zeev, 1996; Yetkin, 2003; Acharya, 2017). A research conducted by Prabowo, et al (2018a) reveals that

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based on the results of the national examinations in 2013 to 2016, mathematics is the most difficult subject to be mastered by students at the junior high school level compared to other subjects tested on the national examination. Even in 2017, the average score of national exam for junior high school students decreased compared to the previous years (Prabowo, et al, 2019). Thus, the need to know, test, and prove the relationship between Cooperative learning method and learning outcomes should be done by investigating the effect size value generated from studies related to the problem.

One of the factors that affect students' ability to master the material is related to learning methods. Learning should be carried out with a variety of learning methods (Prabowo, 2017). The use of appropriate learning methods can reduce the level of difficulty of mathematics considering mathematics is a subject that is learned from basic education.

Students' mathematics learning achievement can improve well if the communication between the parties, namely students, teachers, schools, parents, or close relatives runs well (Chen & Cheng, 2013). The use of appropriate learning media, both printed and electronic, (Prabowo, et al, 2018b) is also able to improve students' mathematics learning achievement (Li & Ma, 2010). The learning approaches used to provide different results to students' mathematics learning achievement (Wewe, 2017). A collaboration among students to achieve a shared vision can encourage achieving the goal of building each other's ideas collaboratively, supporting one another, criticizing or arguing with each other, solving several problems together which ultimately increase students' achievement collectively (Johnson & Johnson, 1989, 1999; Pimphan, 2001; Johnson et al, 2006; Huang et al, 2017). The cooperative learning method is very popular in the United States and Europe. Among several countries that use the Cooperative learning method are the United States, Britain, Australia, Norway, and Israel (Rattanatumma & Puncreobutr, 2016).

The cooperative learning method utilizes instructional small groups to facilitate the students' in learning and working together to improve their understanding and mutual learning (Johnson et al, 2014). The Center for Social Organizations of Schools of John Hopkins University has developed and evaluated five cooperative-based learning models (Slavin & Cooper, 1989). The five models are (1) Student-Teams Achievement Division (STAD) (Slavin et al, 1984), (2) Team-Game-Tournament (TGT) (Slavin et al, 1984), (3) Cooperative Integrated Reading and Composition (CIRC) (Stevens et al, 1987), (4) Team Assisted Individualization (TAI) (Slavin et al, 1984), and (5) JIGSAW (Slavin et al, 1986).

The cooperative learning method provides a learning experience so that students can collaborate with their peers on various tasks that can improve their cognitive by observing and practicing certain settings to help them internalize cognitive functions and to understand the material provided (Vygotsky, 1978). Cooperative student interaction can help students explain to their peers using their own words so that they can be actively and effectively involved in conveying their ideas which make the cooperative learning method a learning tool at various levels of education in various fields of study (Brown & Campione, 1986; Wittrock, 1986; Steven & Slavin, 1995; Zakaria & Iksan, 2007). There are five important elements in the cooperative learning method (Johnson et al, 1994), namely (a) positive interdependence, (b) promotive interaction, (c) individual accountability, (d) interpersonal and small-group skills, and (e) group processing. The cooperative learning method changes the teacher-centered learning paradigm to be more student-centered (Effandi, 2005).

Several studies have shown that cooperative learning methods can enhance students' learning achievement in mathematics. Thus, it is recommended for mathematics teachers to create an effective learning atmosphere (Slavin et al, 1984; Reid, 1992; Kramasrski & Mevarech, 2003; Ajaja & Eravwoke, 2010; Zakaria et al, 2010; Wyk, 2011, 2012; Zakaria et al, 2013; Tran, 2014; Altun, 2017). The results of this study were obtained with a variety of correlation coefficients (rxy) which can be shown in table 1. The research samples were characterized by transforming the value of t and F to rxy.

Scientific truth must be objective, verifiable, and can be communicated to meet scientific requirements (Suryabrata, 1998). One of the systematic scientific methods that are capable of integrating findings or research results is a meta-analysis (Hunter & Schmidt, 1990; Haidich, 2010). Meta-analysis is a statistical technique that summarizes and corrects empirical findings across independent studies to get a more precise estimate of the relationship between variables, to compile several studies and then analyzes them, and to compare treatments and predicts a particular phenomenon by using appropriate statistics to explain them more broadly (Hunter and Schmidt, 2004; Enwemeka et al, 2004; Green, 2005; Junhua et al, 2007; Riley et al, 2010; Kilpeläinen et al, 2011; Koricheva & Mengersen, 2013; White, 2015; Stanley et al, 2013;).

The function of Meta-analysis is to measure the errors or range limitations, both directly and indirectly, so that it can provide corrections to research results, quantitatively combine other studies objectively by focusing on the effect size, avoid biased publications, provide good decisions in a short amount of time, and summarize various studies (Hunter and Schmidt, 2015; King & He, 2006; Riley et al, 2010; Green, 2005; Akobeng, 2005).

Based on the description, the researchers were interested to conduct research using a quantitative meta-analysis approach. The research objectives were; (1) knowing the value of the effect size based on the relationship of the cooperative learning method and students' mathematics learning achievement in Indonesia and (2) testing or proving the relationship of the cooperative learning method and students' mathematical learning in Indonesia.

METHODS

The design of this research was quantitative meta-analysis designs. Quantitative meta-analysis was done by combining two or more published research results through statistical analysis and review (Wolf, 1986; Hunter & Schmidt, 2004; Haidich, 2010).

The steps of the research were: (a) determining several interesting theoretical relationships, (b) gathering the population to obtain the data, (c) determining the specific study, (d) assessing the effect size, (e) examining the effect size, (f) analyzing the impacts of moderation variables, and (g) interpreting and reporting the results. The fixed effects and random effects in the meta-analysis were determined by assuming that all studies had the same or different treatment effects (Riley et al, 2011).

Research publications related to the influence or relationship of cooperative learning method on mathematics learning achievement. To analyze the data, Jeffrey's Amazing Statistics Program (JASP. 0.11. 1.0. JASP) software was utilized. The stages of data analysis were based on opinions from Grasman (2017), Borenstein et al, (2009), and Hunter & Schmidt (2004) which consisted of (a) analyzing sample characteristics, (b) performing heterogeneity test, (c) checking publication biases, (d) estimating the effect size value and

estimating the summary of effect size, (e) making forest plots, and (f) calculating p-values to test the hypotheses.

RESULTS AND DISCUSSION

The initial stages of the analysis were carried out to achieve the research objectives by describing the characteristics of the research samples as presented in table 1.

Table 1. Characteristics of the Research Sample

No	Year	Researchers	N	F	t	r	Characteristics
1	2013	Putu, I Made, & I Made Kirna	119	21,996	4,68999	0.03854	Junior High School Students
2	2015	Ni Luh, Nyoman, & I Made	12		32,756	0,76611	Elementary School Students
3	2014	Ni Komang, I Nyoman, & I Wayan	75		7.94	0.0981	Elementary School Students
4	2014	Ni Luh, Dewa, & Ni Nyoman	50		3.88	0.07479	Elementary School Students
5	2016	Wilibaldus Bhoke	80	2.955	1.71901	0.02156	Elementary School Students
6	2017	Test Cahyaningsih1	73		2,073	0.02837	Elementary School Students
7	2016 Post-	Hadi Pradana	20	6.96	2.63818	0.12783	Elementary School Students
8	2013	Kd Dian, I Gst.	32		15.46	0.34008	Elementary School Students
9	2016	Ai Solihah	40		3.86	0.09221	Vocational High School Students
10	2016	Ummi Rosyidah	28		1.87	0.0671	Junior High School Students
11	2011	La Singga	20	3.362	1.83358	0.09245	Junior High School Students
12	2014	Mira, Faad, and Abd	180	9.92	3.1496	0.01739	Junior High School Students
13	2016	Mohammed, Muliani	20	0, 69	0.83126	0.04414	Junior High School Students
14	2017	Sri, Tohimin Apriyanto	30		3.3	0.10543	Elementary School Students
15	2016	Jhoni Warmansyah	44	14.5	3.80789	0.08313	Elementary School Students
16	2013	I Made, I Wayan, & Sariyasa	55			0,235	Elementary School Students

The table shows that the results of published research, both in journals and proceedings, within 2011 to 2017 display a positive relationship between cooperative learning method and students' mathematics learning achievement with a variety of samples and correlation values. The samples of each research were of at least 12 students to 10 students and the correlation values ranging from 0.01 to 0.76. The description of the year and place of publication can be seen in Figures 1 and 2.

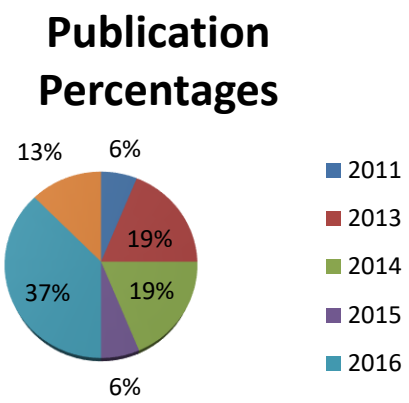

Figure 1. Publication Percentages

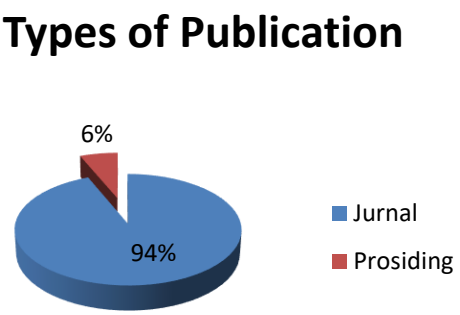

Figure 2. Types of Publication

Based on figure 1, the percentage of publication on the relationship between cooperative learning method and mathematics learning achievement in the 2011-2017 interval was mostly produced in 2016 which consisted of 37% of the whole research. Only a small number of research was published in 2011 and 2016 by only 6%. The type of publication at the same year interval was mostly in the form of journals by 94% and Proceedings by 6%. The most popular journal was the national journal.

The second stage of the research was the heterogeneity test to determine whether the fixed effects or the random effects that should have been used.

Table 2. Fixed and Random Effects

	Q	df	P
Omnibus test of Model Coefficients	6,554	1	0.010
Test of Residual Heterogeneity	48,351	15	< .001

The table shows the Q value on the heterogeneity residual test was 48, 351 with p-value < 0.001 which meant that the publications used in this study were based on the heterogeneity correlation value. This was consistent with the heterogeneity residual test estimate where the value of τ^2 was 0.039 and the value of τ was 0.197 (greater than zero). The value of I^2 was 73.083% which was approaching 100% so that the meta-analysis used to calculate publication bias, effect size value, a summary of effect size, and the p-value was the random effects.

The third stage was done by checking publication bias using random effects by utilizing the rank correlation test for funnel plot asymmetry. The Kendall's value **τ** can be seen in Table 3 and the regression test for Funnel plot asymmetry (Egger's test) for z value can be seen in table 4.

Table 3. Rank Correlation Test for Funnel Plot Asymmetry

	Kendall'sτ	P
Rank test	0.247	0.189

Table 4. Regression Test for Funnel Plot Asymmetry (Egger's test)

	z	p
sei	0.683	0.495

Based on the tables, the obtained Kendall's value **τ** was 0.247 with the p-value of 0.189 and the z value of 0.683 with the p-value of 0.495. It means that there was no publication bias because the p-values of the two tests were greater than 0.05. The tests' results were in accordance with the funnel plot based on the diagnostic trim-fill analysis presented in figure 3 and Figure 4.

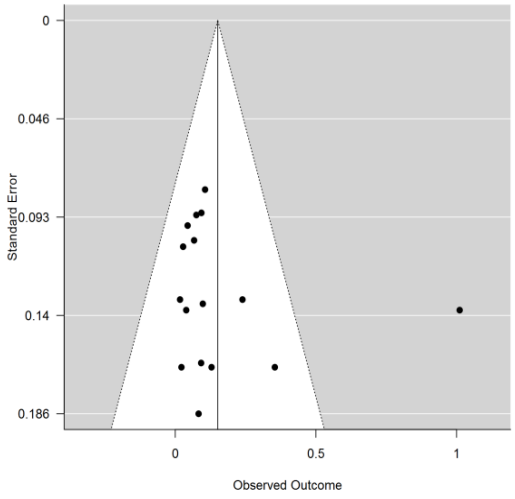

Figure 3. Initial Funnel Plot

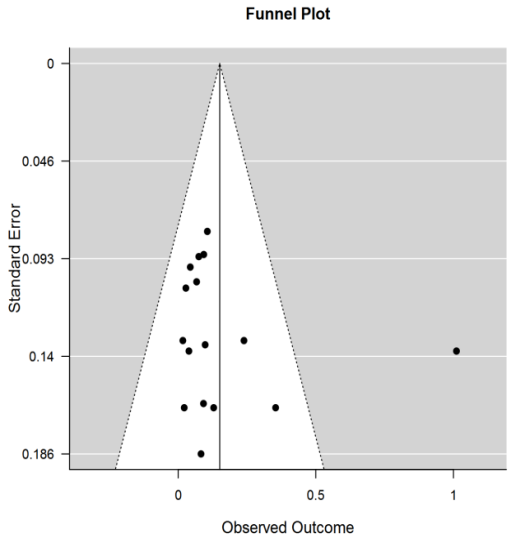

Figure 4. Funnel Plot Diagnostic Trim-Fill Analysis

Based on Figure 3 and Figure 4, the funnel plots show no difference between the initial funnel plot before the diagnostic and funnel plot after the diagnostic. The images show no publication bias so that no additional samples were made in the data analysis. The fourth stage was analyzing the summary effect size. In this stage, the values of the effect size of each publication are presented in Figure 5.

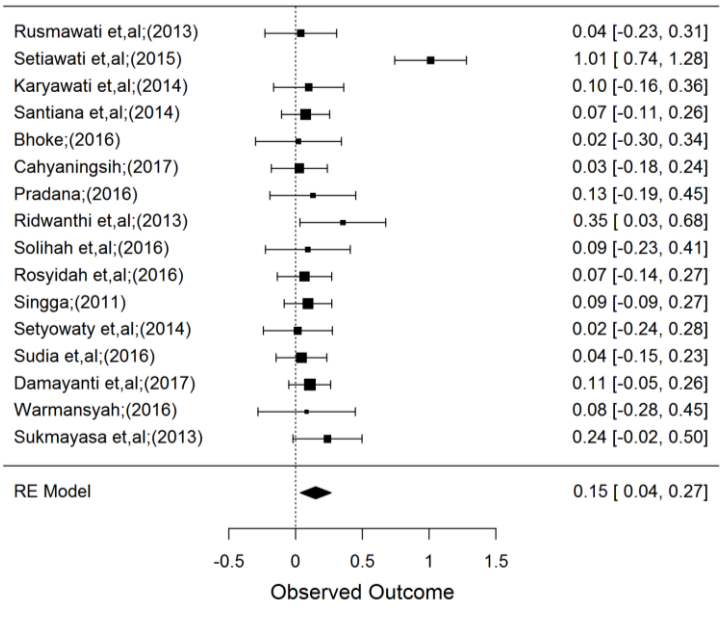

Figure 5. Forest Plot Random Fixed

Figure 5 shows each value of effect size with their respective intervals, for example, the publication by Rusnawati et, al with the value of 0.04 at -0, 23, and 0.31 intervals; the publication by Pradana with the value of 0.13 at -0.19 and 0.45 intervals; and the publication by Sukmayasa with the value of 0.24 at -0.02 and 0.50 intervals. The average effect size value was 0.15 at 0.04 and 0.27 intervals, so the variance and standard error can be determined.

One-tailed t-test with a significance level of 5% and a p-value of 0.05 was performed. The p-value obtained was 0.00621. Because the p-value obtained was 0.00621 which was smaller than 0.05, it could be concluded that Ho was rejected. It means that there was a significant relationship between learning achievement and the cooperative learning method.

Mathematical learning methods that are appropriate to students' characteristics will improve students' mathematics learning achievement (Hariyati et al, 2013; Hong, 1996; Kebritchi et al, 2010). The cooperative learning method is one method that has been developed in several countries and gives good results on students' mathematics learning achievement (Rattanatumma & Puncreobutr, 2016). Students' achievement is also influenced by other factors, namely motivation (Mata et al, 2012), emotions (Ahmed et al, 2013), and gender differences (Fennema & Sherman, 1977). Students' mathematics learning achievement is a main indicator of the ability to absorb the material provided.

Based on the results of the analysis of 16 research publications in Indonesia on the cooperative learning method and students' learning achievement through the meta-analysis approach, the average effect size value was 0.15. According to Cohen et al (2007), the effect size should be 0 to 1. It means that the effect size value of this research was categorized in the low category. However, there was no publication bias which showed that the research sample used was in accordance with the criteria or valid. The absence of publication bias signified that no publication was lost in the analysis, so there was no need to add more publication to be analyzed.

The positive value of the average effect size showed that the cooperative learning method was one of the variables that had a positive relationship with students' mathematics learning achievement at school, at home, or in other formal institutions. The right learning method can motivate students to learn mathematics. On the contrary, a learning method that does not pay attention to students' characteristics can reduce their motivation in learning mathematics. Mathematics learning methods can improve students' mathematical communication skills even though the material learned is of higher difficulty (Artut, 2009; Tarim, 2009; Tinungki, 2015; Hasanah & Surya, 2017; Maonde et al , 2015).

The results of hypothesis testing at a significant level of 5% indicated that there was a significant relationship between the cooperative learning method and students' mathematics learning achievement. To that end, in teaching mathematics, each instructor should master the cooperative learning method as one of the learning methods that can improve students' mathematics learning achievement. One step that can be done is to form small groups to discuss each topic to make it easier for teachers to apply the cooperative learning method in the classroom.

CONCLUSIONS

The cooperative learning method can encourage students to improve their learning achievement by forming small groups in the classroom. Although mathematics is a difficult subject, the right learning method can motivate the students to learn and complete the tasks given. The meta-analysis approach showed that there was a positive influence between cooperative learning method and students' achievement in Indonesia with an average effect size value of 0.15 at 0.04 and 0.27 intervals, the variance of 0.0028, and standard error of 0.053 which indicated that there was no publication bias. The success of students' mathematics learning will encourage them to improve their ability in learning mathematics.

The cooperative learning method is one indicator that has been proven to have a positive impact on students' achievement. For this reason, the studies related to cooperative learning methods at schools are needed.

AUTHOR CONTRIBUTIONS STATEMENT

All authors contributed to the design research, product development processes, analyzing data, writing manuscripts, and approving final manuscripts.

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