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The Effectiveness of Innovative Learning on Mathematical Problem-Solving Ability: A Meta-Analysis

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Abstract

Learning problem-solving skills emphasizes reasoning abilities to determine conclusions based on-premises, determining alternative solutions in decision making, thinking creatively in building alternatives to get keys, and critical thinking to evaluate the best solutions in answering problems. This study aims to identify biased publications using the trim and fill method in determining the effectiveness of learning on the problem-solving abilities of junior high school students. This research is a quantitative study with a meta-analysis approach. Data collection based on quantifiable variable numerical information analysis results from mathematical problem-solving abilities in two different learning groups. The data analysis technique uses bias publication analysis with the trim and fills method with the analysis procedure of calculating the effect size, heterogeneity test, calculating the summary effect using the random-effect model, and forest-plot analysis and biased publication analysis. The results showed no publication bias. The validity of differences in innovative and conventional learning effectiveness was valid on junior high school students' mathematics problem-solving skills.

Introduction

Skills in solving test items require simple mathematical abilities or high-level abilities such as solving math problems. Mathematical problem-solving skills concerning issues involve many procedures to obtain solutions known as multi-step problems, while simple mathematical skills relate to single-step issues. Practices in problem-solving skills consist of reasoning, decision making, creative thinking, and critical thinking skills (Mayer & Wittrock, 2006). Reasoning refers to solving problems by making conclusions from premises using logical rules based on deduction or induction. As for the decision-making procedure, one can choose one or more alternatives based on several criteria. Then, creative thinking is a step or process to build choices that match the requirements to reach a solution, while critical thinking by evaluating alternative solutions according to criteria, such as determining the best answer to each problem.

The problem that is of concern to education observers is students' low ability to solve mathematical problems. Rahmawati & Retnawati (2019) showed that grade IX students' difficulties in solving PISA questions consisted of reading errors, understanding questions, transforming, processing skills, and coding. Mathematical problem-solving abilities become a benchmark component in international student assessments. The International Student Assessment (PISA) test held by the Organization for Economic Cooperation and Development (OECD) in 2018 showed that the average score for Indonesian students was 379, decreasing in value compared to 2015. The assessment result data is a reference for improving the education system existing in Indonesia with attention to the curriculum. The central object in education is educators who have a direct role in carrying out learning to students.

Several research results indicate that students' motivation to learn mathematics affects their low problem-solving ability. The research results by Wulandari et al. (2018) stated that the contribution of the influence of student motivation on students' mathematical problem-solving skills was 10.82%. Another factor that affects students' difficulty in solving problems, such as research conducted by Sugiarti & Retnawati (2019), states the test of students in solving algebraic problems in the form of story problems. Another factor that has the most influence is the teacher's learning by carrying out conventional understanding. Conventional education focuses on routine questions, while innovative education focuses on problem-solving problems that are not routine.

Innovative learning has provided many benefits in increasing students' mathematical problem-solving abilities. Data from the grouping research studies in this study are in journal publications based on measured variables, namely the mathematical problem-solving skills of junior high school students for innovative learning in the experimental group and conventional learning for the control group. The results of grouping research studies consisting of 31 studies indicate differences in students' mathematical problem-solving abilities with innovation compared to conventional learning. A systematic review of data grouping is based on independent variables consisting of models, strategies, methods, or approaches to the dependent variable, namely the mathematics problem-solving abilities of junior high school students. The data analysis used a meta-analysis approach to identify publication bias in determining the effectiveness of innovative learning. Numerical information consists of the mean and standard deviation and the sample size for the experimental group and the control group as initial data to calculate each study's effect size.

Not many studies use research methods with a meta-analysis approach to identify publication bias. Several studies conducted, such as Candra & Retnawati (2020), show no publication bias in looking at the relationship between constructivism learning and civics education learning outcomes. In his research using the trim and fill method using a fixed-effect model. Subsequent research by Retnawati & Subarkah (2018) also uses a random-effects model with the trim and fill method, showing no publication bias in identifying scientific learning models capable of improving student learning outcomes. The following relevant research was carried out by Sugano & Nabua (2020) using a random-effects model to see the effect of learning methods on academic performance in secondary chemistry learning. It was discovered that using multiple learning techniques in chemistry had a different influence on student achievement than traditional teaching methods. Next, the study uses a meta-analysis approach to see the effect of constructivist learning on academic achievement, retention, and student attitudes based on the identification of N fail-safe values. The results show that the constructivist learning approach positively affects students' academic achievement, retention, and attitudes (Semerci & Batdi, 2015).

Furthermore, the study looked at the constructivist learning approach's influence on student achievement by reviewing the relevant literature. As many as 53 research studies showed, constructivist learning positively affected student achievement compared to conventional teaching methods and, based on funnel plots, showed biased publications containing open circles (Ayaz & Sekerci, 2015). Other research using a meta-analysis approach by looking at the effectiveness of cooperative learning in mathematics shows that the average effect of cooperative learning on student mathematics achievement is significant at the 0.05 level. Moreover, the percentage of student achievement is 29.16% (Ugwuanyi, 2015). Demirel & Dagyar (2016) also carried out the meta-analysis research approach, showing that problem-based learning effectively helps students get positive attitudes towards learning. Also, it shows there is a publication bias using a random-effects model.

Next, Capar and Tarim (2015) show that cooperative learning methods are more influential than conventional methods on student achievement and attitudes. Other research looking at the effect of cooperative learning on mathematics achievement in Turkey shows that cooperative learning positively affects mathematics learning outcomes and shows biased publication (Turgut & Turgut, 2018). Based on the problems and relevant research above, this study aims to identify biased publications by using the trim and fill model in determining the effectiveness of innovative learning on the mathematics problem-solving abilities of junior high school students. This study's analysis procedure consisted of the effect size calculation analysis, heterogeneity test, summary effect calculation analysis, forest-plot analysis, and bias publication analysis based on the identification of funnel plots using trim and fill models.

Method

This type of research is a quantitative study using a meta-analysis approach. Meta-analysis is a quantitative statistical method for aggregating and statistically evaluating reported descriptive from several relevant published and unpublished research studies that discuss and test the same conceptual research questions and hypotheses (Glass, 1976; Hedges and Olkin, 1985). In general, research with a meta-analysis approach consists of six main steps (Durlak, 1998), namely the determination of research questions, literature review, study coding, calculation of the effect size index, statistical analysis of the effect size distribution, and results and conclusions. Then, the stages according to Borenstein et al., 2009; Card, 2012; Cooper, 2010 consists of (1) formulating the problem, (2) searching the literature, (3) gathering information and findings from individual studies, (4) evaluating the quality of the study, (5) analyzing and interpreting the study results, and (6) interpreting the results or evidence. In this study, meta-analysis used research data related to innovative learning effectiveness on junior high school students' mathematics problem-solving abilities.

The research data was obtained based on a literature review by collecting and analyzing numerical information involving measurable variables, namely the results of mathematical problem-solving abilities in two different groups. A variation or contrast in the measured variable between the experimental and control groups is referred to as a treatment effect (Lipsey & Wilson, 2001). Based on the vector models, techniques, processes, or learning approaches of the two separate groups on the impact of mathematical problem-solving skills, the mean, standard deviation, and sample size were both measured and evaluated numerically. The research data coding based on the components consisted of the researcher with the study's year, the sample size, the mean, the standard deviation of each of the two groups. While the independent variable consists of models, strategies, methods, or approaches, the dependent variable is junior high school students' problem-solving abilities.

The data analysis technique used was publication bias analysis using the trim and fill method (Duval & Tweedie, 2000a) to determine innovative learning effectiveness on mathematical problem-solving abilities. Use of this method to estimate the number of studies lost due to removing the most extreme results on one side of the funnel plot in the meta-analysis (Duval & Tweedie, 2000b). So, if there is publication bias in the study, the funnel plot will be asymmetrical. Conversely, if there is no publication bias in the study, the funnel plot will be symmetrically distributed (Cooper, 2016). The impact size was calculated in the preliminary study using a sample on a different scale (Cheung, 2015), which was calculated by dividing the mean scores between the two groups by the standardized mean difference. The analysis of heterogeneity testing uses the calculation of Q-statistical analysis (p-value) and I^2 to determine variability based on sampling error or population variance. For τ^2, it is used to calculate the effect size weights using the fixed-effect model or random effect model (Retnawati et al., 2018). Furthermore, according to Lipsey & Wilson (2001), the p-value is lower than the significance level. It meets the heterogeneity test, which indicates that the collection of research studies is more than one distribution.

A summary effect calculation analysis is carried out using the fixed-effect model or the random-effect model based on the heterogeneity test results. Next, forest-plot analysis and interpretation based on the results of summary effect calculations using the fixed-effect model or random-effect model and bias publication analysis based on identifying the funnel plot using the trim and fill model. The statistical analyses' findings were then interpreted, according to Pigott (2012); Sánchez-Meca & Marn-Martnez (2010).

Results

Data Encoding

The dependent variable is used to group the research. Namely, junior high school students' mathematics problem-solving ability, with the independent variable consisting of models, strategies, methods, or learning approaches carried out in the study. The researcher then coded the data according to the study year, sample size, mean, standard deviation of each of the two classes, and independent and dependent variables. Table 1 summarizes the findings of the study data coding.

Table 1. Results of Data Coding

Researcher and Year of Research	Experiment Group			Control Group			Independent Variable	Dependent Variable
	$\bar{x}_e$	s_e	n_e	$\bar{x}_c$	s_c	n_c		
Agustin et al., 2014	81.20	11.81	25	74.79	15.25	24	Cabri-3D Assisted CPS Learning Model	Mathematical Problem-Solving Ability
Ainun &	86.44	6.61	18	81.00	6.21	21	Problem-Based	Mathematical

Almukarramah, 2018							Learning Model	Problem-Solving Ability
Aisyah, 2016	81.91	11.51	28	64.57	15.09	28	Geogebra Software Assisted Problem Based Learning Model	Mathematical Problem-Solving Ability
Aprianti & Kesumawati, 2019	79.67	10.05	30	69.70	8.98	30	Auditory Intellectually Repetition (AIR) Learning Model	Mathematical Problem-Solving Ability
Astriani et al., 2017	76.94	7.76	20	68.10	10.47	20	Problem-Based Learning Model	Mathematical Problem-Solving Ability
Bella et al., 2019	78.13	9.00	30	71.70	8.50	30	The Power of Two Learning model	Mathematical Problem-Solving Ability
Effendi, 2012	17.97	6.43	36	12.00	4.61	35	Guided Discovery Method	Mathematical Problem-Solving Ability
Endah et al., 2019	84.61	10.48	29	75.06	14.48	29	LAPS-Heuristics Learning Model	Mathematical Problem-Solving Ability
Inayah, 2018	14.97	3.13	36	10.60	3.26	35	Quantum Learning Model	Mathematical Problem-Solving Ability
Islamiah et al., 2018	10.66	4.89	38	9.53	3.89	38	Guided Inquiry Methods	Mathematical Problem-Solving Ability
Kurniyawati et al., 2019	84.12	12.41	31	77.27	18.89	31	Problem-Based Learning Model	Mathematical Problem-Solving Ability
Lestari, 2016	48.11	10.75	37	36.17	9.90	37	Project Assisted Group Investigation Learning Model	Mathematical Problem-Solving Ability
Liu, 2019	85.43	10.46	28	71.48	24.12	27	Problem-Based Learning Model	Mathematical Problem-Solving Ability
Lubis et al., 2018	53.40	2.52	20	42.90	2.93	20	Creative Problem Solving Learning Model	Mathematical Problem-Solving Ability
Mardaleni et al., 2018	72.62	12.49	29	67.88	14.55	29	Scaffolding Learning Strategy	Mathematical Problem-Solving Ability
Murti et al., 2019	77.00	7.70	31	69.46	9.50	30	SAVI Learning	Mathematical

							Model	Problem-Solving Ability
Nainggolan, 2015	38.10	4.40	80	33.20	4.61	81	Realistic Mathematical Approach	Mathematical Problem-Solving Ability
Permatasari & Margana, 2014	89.89	5.38	36	86.56	6.09	36	Treffinger Learning Model	Mathematical Problem-Solving Ability
Rahayu, 2012	20.40	8.66	40	16.58	8.61	40	Contextual Learning Approach	Mathematical Problem-Solving Ability
Rahmatika et al., 2019	64.30	21.52	28	54.96	20.20	29	Situation-Based Learning Model	Mathematical Problem-Solving Ability
Rasmin et al., 2019	44.20	13.59	22	29.79	10.48	24	Problem Posing Approach	Mathematical Problem-Solving Ability
Rismaini, 2016	19.62	5.00	27	15.43	4.65	28	Cycle Learning Model	Mathematical Problem-Solving Ability
Septianingsih et al., 2015	30.00	3.15	21	25.09	4.08	22	The Power of Two Learning Strategies	Mathematical Problem-Solving Ability
Siregar, 2017	33.19	8.79	36	22.62	7.43	37	Problem-Based Learning Model	Mathematical Problem-Solving Ability
Sugesti et al., 2018	80.75	5.12	32	68.12	4.92	32	SAVI Learning Model	Mathematical Problem-Solving Ability
Suratmi & Purnami, 2017	43.77	0.08	31	37.00	7.18	32	Metacognitive Strategy	Mathematical Problem-Solving Ability
Ulvah & Apriansyah, 2016	4.78	1.68	25	3.62	3.54	26	SAVI Learning Model	Mathematical Problem-Solving Ability
Utami et al., 2016	61.86	21.32	29	49.66	19.66	28	Open-Ended Approach	Mathematical Problem-Solving Ability
Yuhani et al., 2018	42.91	11.59	34	37.62	12.25	34	Problem-Based Approach	Mathematical Problem-Solving Ability
Yulian, 2016	30.70	5.36	40	22.95	5.69	40	Algebrator Software-Assisted Inquiry Methods	Mathematical Problem-Solving Ability

Zulkipli & Ansori, 2018	73.13	10.29	20	63.59	11.81	20	Realistic Mathematical Approach	Mathematical Problem-Solving Ability

Table 1 above provides information related to research data related to the effectiveness of models, strategies, methods, or learning approaches on junior high school students' mathematics problem-solving abilities. The research data of 31 research studies contain numerical information consisting of mean, standard deviation, and sample size for each experimental and control group. Then, other numerical information shows the average results of the study with different scales. The following effect size calculation analysis uses the standardized mean difference by dividing the difference between the mean scores of the two groups by the combined standard deviation.

Effect Size Calculation Analysis

Effect size is a procedure of combining and comparing statistically based on coding quantitative research findings. For each variable and measure involved, the effect size statistics generate structured statistics with numerical information that can be interpreted consistently (Retnawati et al., 2018). This study's quantitative research results were based on independent variables, such as learning to improve junior high school students' math problem-solving abilities. In this study, the quantitative research data findings were based on independent variables, namely learning towards junior high school students' mathematics problem-solving skills. Due to the numerical information, namely the average mathematical problem-solving ability given on a different scale, the effect size calculation analysis uses the standardized mean difference by dividing the mean raw scores by the standard deviation. The following shows the effect size calculation results based on numerical information for each research data in Table 1.

Table 2. Result of Effect Size Calculation Component

Researcher and Year of Research	S_{within}	d	V_d	SE_d
Agustin et al., 2014	13.603	0.471	0.084	0.290
Ainun & Almukarramah, 2018	6.397	0.850	0.112	0.335
Aisyah, 2016	13.420	1.292	0.086	0.294
Aprianti & Kesumawati, 2019	9.530	1.046	0.076	0.275
Astriani et al., 2017	9.215	0.959	0.111	0.334
Bella et al., 2019	8.754	0.735	0.071	0.267
Effendi, 2012	5.608	1.065	0.064	0.254
Endah et al., 2019	12.639	0.756	0.074	0.272
Inayah, 2018	3.195	1.368	0.070	0.264
Islamiah et al., 2018	4.418	0.256	0.053	0.230
Kurniyawati et al., 2019	15.982	0.429	0.066	0.257
Lestari, 2016	0.334	1.155	0.063	0.251
Liu, 2019	18.470	0.755	0.078	0.279
Lubis et al., 2018	2.733	3.842	0.285	0.533
Mardaleni et al., 2018	13.559	0.350	0.070	0.265

Murti et al., 2019	8.632	0.874	0.072	0.268
Nainggolan, 2015	4.507	1.087	0.029	0.169
Permatasari & Margana, 2014	5.746	0.580	0.058	0.241
Rahayu, 2012	8.635	0.442	0.051	0.226
Rahmatika et al., 2019	20.858	0.448	0.072	0.268
Rasmin et al., 2019	12.064	1.194	0.103	0.320
Rismaini, 2016	4.825	0.868	0.080	0.282
Septianingsih et al., 2015	3.656	1.343	0.114	0.338
Siregar, 2017	8.129	1.300	0.066	0.258
Sugesti et al., 2018	5.021	2.515	0.112	0.335
Suratmi & Purnami, 2017	2.789	0.420	0.080	0.283
Ulvah & Apriansyah, 2016	20.522	0.594	0.073	0.271
Utami et al., 2016	11.925	0.444	0.060	0.246
Yuhani et al., 2018	5.527	1.402	0.062	0.250
Yulian, 2016	11.076	0.861	0.109	0.331

Table 2 above shows the analysis process of calculating the effect size for each research data where S_{within} is the combined standard deviation of the two groups. Then, the effect size is obtained by dividing the mean difference between the two groups by the combined standard deviation of the two groups. At the same time, V_d and SE_d are the variances and standard error of the effect size. However, according to Hedges (1981), the estimation equation for the difference in the sample mean tends to produce a more significant estimated value based on the absolute value of the population parameter δ. Then, to minimize bias by converting each effect size value d to effect size g using J's correction factor. The following shows the effect size calculation results based on the conversion of numerical information for each research data in Table 2.

Table 3. Result of Calculation of Effect Size Conversion

Researcher and Year of Research	J	g	V_g	SE_g
Agustin et al., 2014	0.984	0.464	0.082	0.290
Ainun & Almukarramah, 2018	0.980	0.833	0.103	0.335
Aisyah, 2016	0.986	1.274	0.071	0.294
Aprianti & Kesumawati, 2019	0.987	1.033	0.067	0.275
Astriani et al., 2017	0.980	0.940	0.100	0.334
Bella et al., 2019	0.987	0.725	0.067	0.267
Effendi, 2012	0.989	1.053	0.056	0.254
Endah et al., 2019	0.987	0.745	0.069	0.272
Inayah, 2018	0.989	1.353	0.056	0.264
Islamiah et al., 2018	0.990	0.253	0.053	0.230
Kurniyawati et al., 2019	0.987	0.423	0.065	0.257
Lestari, 2016	0.990	1.143	0.054	0.251
Liu, 2019	0.986	0.745	0.073	0.279
Lubis et al., 2018	0.980	3.766	0.100	0.533
Mardaleni et al., 2018	0.986	0.345	0.069	0.265
Murti et al., 2019	0.987	0.862	0.066	0.268

Nainggolan, 2015	4.507	1.087	0.029	0.169
Permatasari & Margana, 2014	5.746	0.580	0.058	0.241
Rahayu, 2012	8.635	0.442	0.051	0.226
Rahmatika et al., 2019	20.858	0.448	0.072	0.268
Rasmin et al., 2019	12.064	1.194	0.103	0.320
Rismaini, 2016	4.825	0.868	0.080	0.282
Septianingsih et al., 2015	3.656	1.343	0.114	0.338
Siregar, 2017	8.129	1.300	0.066	0.258
Sugesti et al., 2018	5.021	2.515	0.112	0.335
Suratmi & Purnami, 2017	2.789	0.420	0.080	0.283
Ulvah & Apriansyah, 2016	20.522	0.594	0.073	0.271
Utami et al., 2016	11.925	0.444	0.060	0.246
Yuhani et al., 2018	5.527	1.402	0.062	0.250
Yulian, 2016	11.076	0.861	0.109	0.331

Table 3 above shows the analysis of the effect size calculation for each research data based on the conversion of the effect size calculation for each research data based on the transformation of d to the effect size g using the correction factor J. The results show that each research data has an effect size smaller than the effect size value based on the formula in the estimation equation for the sample mean difference. Then, for V_g and SE_g are the variance and standard error of the effect size, respectively.

Heterogeneity Test

Heterogeneity assumption test is a test conducted to identify variability for each research result that occurs not only influenced by sampling error but population variability or variance from the proper effect size. The heterogeneity test's effects are used to calculate the summary effect using a fixed-effect or random-effect model. Then, the analysis of heterogeneity testing uses Q-statistic (p-value) calculation analysis and I^2 and τ^2. The size of the variance around the overview effect is calculated using the Q-statistical estimation analysis. At the same time, I^2 provides an overview of the proportion of variance measures in a percentage scale, namely 0 up to 100 percent. Meanwhile, using either the fixed-effects or random-effects models, formula τ^2 is used to measure the effect size's weight.

Table 4. Result of Calculation of Effect Size Conversion

Researcher and Year of Research	w	wg	wg^2
Agustin, et al., 2014	12.245	5.682	2.636
Ainun & Almukarramah, 2018	9.692	8.073	6.725
Aisyah, 2016	14.000	17.836	22.723
Aprianti & Kesumawati, 2019	15.000	15.495	16.006
Astriani, et al., 2017	10.000	9.400	8.836
Bella, et al., 2019	15.000	10.875	7.884
Effendi, 2012	17.746	18.687	19.677
Endah, et al., 2019	14.500	10.803	8.048

Inayah, 2018	17.746	24.010	32.486
Islamiah, et al., 2018	19.000	4.807	1.216
Kurniyawati, et al., 2019	15.500	6.557	2.773
Lestari, 2016	18.500	21.146	24.169
Liu, 2019	13.745	10.240	7.629
Lubis, dkk., 2018	10.000	37.660	141.828
Mardaleni, dkk., 2018	14.500	5.003	1.726
Murti, dkk., 2019	15.246	13.142	11.328
Nainggolan, 2015	40.248	43.548	47.119
Permatasari & Margana, 2014	18.000	10.314	5.910
Rahayu, 2012	20.000	8.760	3.837
Rahmatika, et al., 2019	14.246	6.297	2.783
Rasmin, et al., 2019	11.478	13.475	15.820
Rismaini, 2016	13.745	11.766	10.071
Septianingsih, et al., 2015	10.744	14.161	18.664
Siregar, 2017	18.247	23.484	30.224
Sugesti, et al., 2018	16.000	39.760	98.804
Ulvah & Apriansyah, 2016	15.746	20.564	26.857
Utami, et al., 2016	12.745	5.225	2.142
Yuhani, et al., 2018	14.246	8.348	4.892
Yulian, 2016	17.000	7.463	3.276
Zulkipli & Ansori, 2018	20.000	27.780	38.586

Table 4 above shows the heterogeneity test calculations' analysis with $\sum w$ = 484.65, $\sum wg$ = 468.799, and $\sum wg^2$ = 631.801, so that Q = 178.536 and df = 30 are obtained $Q > df$. The results of the analysis of the following calculations are obtained I^2 =83.197% and I^2 >25%. Both of these indicate that the products of grouping research data based on independent variables, namely models, strategies, methods, or learning approaches to the dependent variable problem-solving abilities, meet the assumption of heterogeneity. It means that the variability for each research result that occurs is not only influenced by sampling errors but by population variability or variance from the proper effect size. Because the data grouping products meet the assumption of heterogeneity, the effect summary analysis uses a random-effect model (Borenstein et al., 2009) by considering the sampling error factors and population variability that cause inaccuracies in estimating the effect size.

Analysis of Summary Effect Calculations

The summary effect is a summary or general description of the effect size to be observed consisting of research studies based on a sample size and characteristics review. Analysis of the summary effect calculation uses a random-effects model by considering the sampling error and population variables, namely the proper effect size. The analysis procedure for calculating the effect summary using the random-effects model consists of calculating the weight, calculating the effect summary, variance, standard error, and the lower and upper limits of the summary effects. The following analysis calculates the value from the summary effect. It performs hypothesis testing related to differences in the treatment between the two experimental groups and the control group on solving mathematical problems. The following results are components for calculating the mean, variance, and standard error of the summary effect based on the effect size g in Table 5.

Table 5. Summary Effect Component Calculation Results

Researcher and Year of Research	w	w_R	w_R^2
Agustin, et al., 2014	0.464	2.503	1.161
Ainun & Almukarramah, 2018	0.833	2.375	1.978
Aisyah, 2016	1.274	2.569	3.273
Aprianti & Kesumawati, 2019	1.033	2.601	2.687
Astriani, et al., 2017	0.940	2.394	2.250
Bella, et al., 2019	0.725	2.601	1.886
Effendi, 2012	1.053	2.673	2.815
Endah, et al., 2019	0.745	2.586	1.927
Inayah, 2018	1.353	2.673	3.617
Islamiah, et al., 2018	0.253	2.700	0.683
Kurniyawati, et al., 2019	0.423	2.616	1.107
Lestari, 2016	1.143	2.689	3.074
Liu, 2019	0.745	2.561	1.908
Lubis, dkk., 2018	3.766	2.394	9.016
Mardaleni, dkk., 2018	0.345	2.586	0.892
Murti, dkk., 2019	0.862	2.608	2.248
Nainggolan, 2015	1.082	2.919	3.158
Permatasari & Margana, 2014	0.573	2.678	1.534
Rahayu, 2012	0.438	2.719	1.191
Rahmatika, et al., 2019	0.442	2.577	1.139
Rasmin, et al., 2019	1.174	2.470	2.900
Rismaini, 2016	0.856	2.561	2.192
Septianingsih, et al., 2015	1.318	2.434	3.208
Siregar, 2017	1.287	2.684	3.454
Sugesti, et al., 2018	2.485	2.630	6.536
Ulvah & Apriansyah, 2016	1.306	2.623	3.426
Utami, et al., 2016	0.41	2.524	1.035
Yuhani, et al., 2018	0.586	2.577	1.510
Yulian, 2016	0.439	2.655	1.166
Zulkipli & Ansori, 2018	1.389	2.719	3.777

Table 5 above shows the summary effect component calculation for each research data based on the effect size using a random-effects model. Based on the calculation analysis component results in Table 5 above, $M_R =$ 0.950, $V_{M_R} =$ 0.002, and $SE_{M_R} =$ 0.045. Based on the value of SE_{M_R}, the lower limit and upper limit of the summary effect using formulas $LL_{M_R} = M_R - (1.96 \times SE_{M_R})$ and $UL_{M_R} = M_R + (1.96 \times SE_{M_R})$, respectively, are obtained by LL_{M_R}= 0.71 and UL_{M_R}= 1.19. The following analysis calculates SE_{M_R} the summary effect's value using the $z_R = \frac{M_R}{SE_{M_R}}$ formula to get $z_R = 8.759$. As a result, the p-value calculation using the two-party test is accepted by $p_{M_R} = 2[1 - \Phi(\pm|z_R|)] = 0$.

Furthermore, the hypothesis testing analysis based on the mean value of the summary effect (M_R) and the z_R value to see the differences in treatment between the two groups is experiment and control on solving mathematical problems. The results of the calculation of the average value of the summary effect using the random effects model are obtained $by\ M_R = 0.95$ with values of $LL_{M_R} = 0.71$ and $UL_{M_R} = 1.19$ at the 95% confidence interval, which is at the lower and upper limit of the summary effect interval with $LL_{M_R} \leq M_R \leq UL_{M_R}$ and does not contain zero. It shows the initial hypothesis, $H_0{:}M_R = 0$, is rejected.

The same results were obtained by concentrating on the z_R value using the p-value, namely $p_{M_R} = 0$ with $p_{M_R} < 0.05$. These two things indicate that the experimental group's treatment with innovative learning is different from the control group using conventional learning on the mathematics problem-solving abilities of junior high school students. There are differences in the effectiveness of innovative and conventional learning models on solving mathematical problems.

Analysis of Forest-Plot

The following analysis is a follow-up analysis to provide an overview regarding the summary effect or effect size of the aggregation using a forest plot. Summary of meta-analysis results in the form of visualization usually uses a forest plot (Borenstein et al., 2009; Card, 2012). In a forest plot, each research study's illustrations are like trees, while all the trees gather to form a forest to provide a synthetic overview (San & Kis, 2018). The forest plot components consist of information on research data based on coding results, the average effect size for each research data with a lower and upper limit, and information on the average summary effect and lower and upper limits using a random-effects model. The forest plot also provides weight information for each effect size and a summary effect. The forest plot analysis results using JASP software are based on the effect size and standard error of the random effects model obtained in Figure 1 below.

Figure 1 above is a forest plot based on the effect size and standard error for each research data using a random-effect model. Based on the effect size criteria for values of 0.00-0.20 low, 0.21-0.50 moderate, 0.51-1.00 high, and matters more than 1.01 are very high (Cohen et al. 2007). We obtained eight research studies with medium effect sizes, ten criteria for high, and 13 others were very high. The above analysis results also provide information that each research data has an average effect size with the amount of weight determined by the area of the black box located at the interval between the lower and upper limits of the effect size. Figure 1 above provides information on the average summary effect with a weighted magnitude based on the area of black diamonds at the interval between the lower and upper limits of the summary effect.

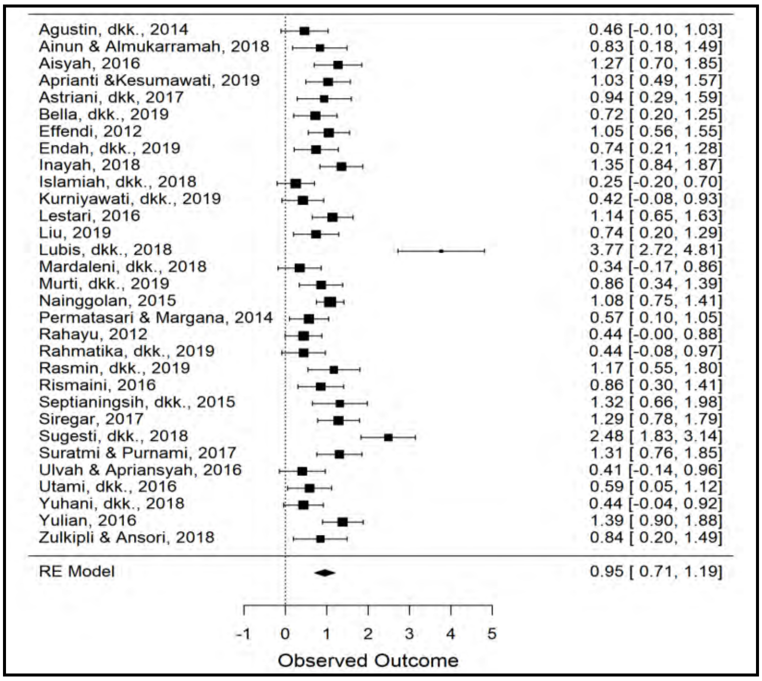


Figure 1. Forest Plot Summary Effect Model Random Effects

The summary effect results using a random effect model of 0.95, which is greater than 0, indicate that innovative learning is more effective than conventional for the consequences of mathematical problem-solving abilities. Also, these results provide information that students' mathematical problem-solving skills increased 95% higher for the experimental group with innovative learning compared to conventional learning. The summary effect results also show a difference in effectiveness between the experimental and control groups on the mathematics problem-solving abilities of junior high school students, with the average location of the summary effect approaching one and moving away from line 0.

Biased Publication Analysis

A systematic review by grouping the independent variable data are models, strategies, methods, or approaches to the dependent variable, which is the mathematics problem-solving ability of high school students. The numerical information on the mean and standard deviation for the experimental group and the control group used the study results in a journal article. The data grouping results show that each research data has a higher average mathematical problem-solving ability using innovative learning compared to conventional learning. In this case, each research data results are a meta-analysis approach by identifying the effect size based on the summary effect in a funnel plot using the trim and fill method to determine the publication bias. The trim and fill method uses an iterative procedure to eliminate the most extreme small studies from the funnel plot's positive side and recalculate each iteration's effect size until the funnel plot becomes symmetrical. The following funnel plot results use the trim and fill method for the effect size and standard error analysis results based on grouping research data using a random-effects model.

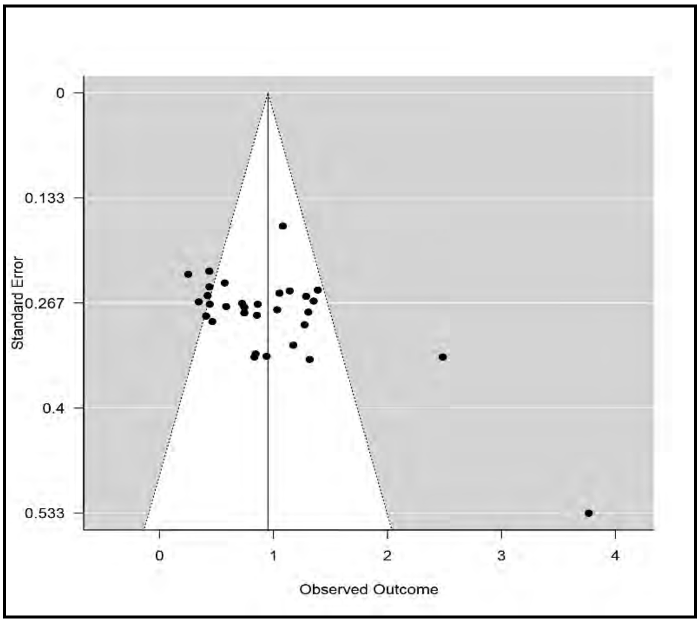
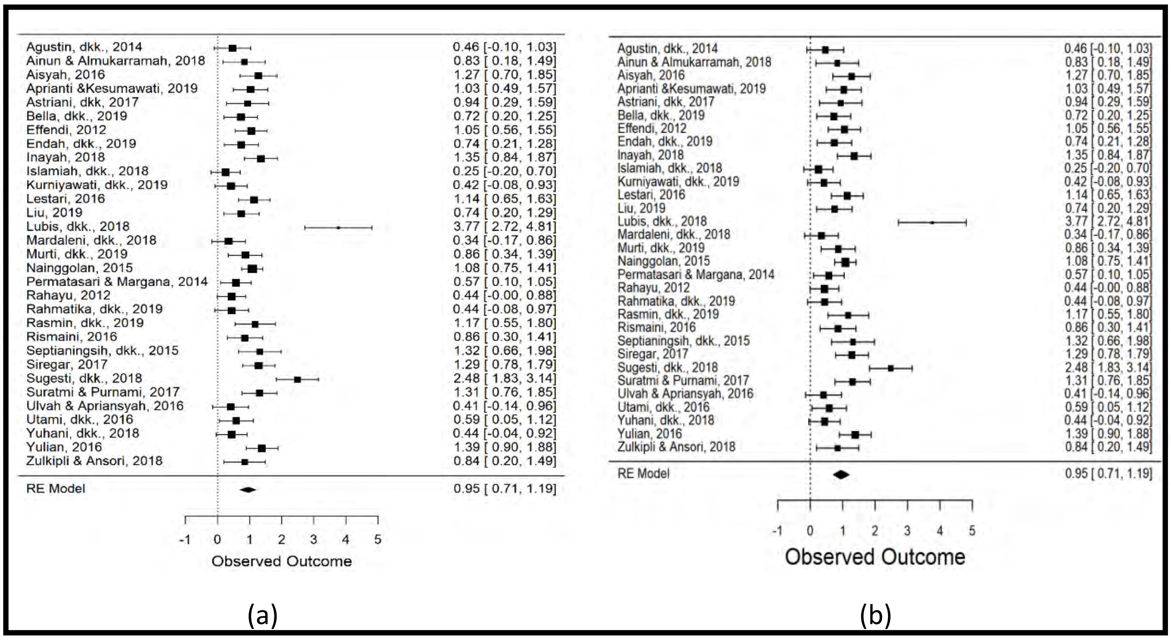


Figure 2. Funnel Plot Using Trim and Fill Models

Figure 2 is a funnel plot using the trim and fill model based on the effect size and standard error for each research data with a random-effects model. The results of the funnel plot consist of closed circles forming a symmetrical structure, which indicates that there is no publication bias. The results provide information that no studies are missing or unpublished. It means that the difference in the effectiveness of learning using innovative and conventional models on the mathematics problem-solving abilities of junior high school students is free from the potential for publication bias. The results were the same using the forest plot analysis before and after using the trim and fill method, as shown in Figure 3.



(a) (b)

Figure 3. Forest Plot (a) Before and (b) After Using the Model

Figure 3 is a forest plot based on the effect size and standard error for each research data and the summary effect using the random-effects model and using the trim and fill model. Figures 3 (a) and (b) show forest plots before and after using the trim and fill models, respectively. The forest plot results above provide information about the same summary effect mean based on the random-effect model before and after using the trim and fill model, namely $M_R = 0.95$. It shows that the validity of differences in innovative and conventional learning effectiveness is valid for junior high school students' mathematics problem-solving abilities.

Discussion

This study aims to identify biased publications by using the trim and fill model in determining the effectiveness of learning on the mathematics problem-solving abilities of junior high school students. Research with a meta-analysis approach in education is the effectiveness of learning in mathematics by Capar & Tarim (2015), showing that cooperative learning is more influential than conventional methods on student achievement and attitudes. Haas (2005) uses experimental research study data to deliver that the six categories of learning positively affect student achievement. Meanwhile, research by Ugwuanyi (2015) shows that cooperative learning effectively affects students' mathematics learning achievement. Research on meta-analysis in higher education learning has been carried out by Kalaian & Kasim (2014), which shows that learning with cooperative and collaborative methods is effective for learning conducted in small groups and can improve student achievement.

In this study, the numerical information data were 31 research studies consisting of mean, standard deviation, and sample size for the experimental and control groups. This study's analysis results consisted of the effect size value, heterogeneity test, summary effect value, forest-plot, and bias publication based on identifying the funnel plot using the trim and fill model. Based on the analysis of the effect size calculation for each research data and also testing the heterogeneity of the data, the results of the effect summary were obtained by using R software, namely $M_R = 0.95$ with a lower limit, $LL_{M_R} = 0.71$, and an upper limit of the effect summary is $UL_{M_R} = 1.19$ so $LL_{M_R} \leq M_R \leq UL_{M_R}$. It shows that the students' mathematical problem-solving abilities increased 95% higher with innovative learning than conventional learning.

The results of the hypothesis testing analysis based on the effect summary mean value and the z_R value. The results show that there are differences in treatment with innovative learning in the experimental group with conventional learning in the control group in improving the mathematics problem-solving abilities of junior high school students. These results show differences in the effectiveness of innovative and conventional learning models on mathematical problem-solving skills. It shows differences in the effectiveness of innovative and conventional learning models on mathematical problem-solving skills.

Other analyses using a forest plot with a random-effects model obtained the same summary effect of 0.95, which is greater than 0, showing that innovative learning is more effective than conventional learning in improving mathematical problem-solving abilities. Besides, these results provide information that students' mathematical problem-solving skills increased 95% higher for the experimental group with innovative learning compared to the control group with conventional learning. Nainggolan (2015) also obtained the same result, which shows that learning using a realistic mathematics approach has a significant effect on conventional learning with a summary effect value greater than 0 in an insignificant direction. Research using a random-effects model conducted by Sugano & Nabua (2020) states that various learning strategies vary effectively on student chemistry learning achievement outcomes compared to conventional learning. One aspect or factor in conventional learning is that it is less effective than innovation learning, namely memorizing activities to develop students' problem-solving abilities and critical thinking skills (Maxwell et al., 2015).

On the other hand, conventional learning methods can improve geometry and number skills in mathematics learning (San & Kis, 2018). The study results using a random-effects model based on a funnel plot and Egger's Regression Intercept test show publication bias. However, in general, Bas & Beyhan (2019) research to see the effect of learning strategies on student achievement. The results show no significant difference between study effect sizes in terms of sample size, type of publication, type of course, duration of implementation, level of learning, school setting, and socioeconomic status. Also, based on 18 research study data, whether published or not, it was found that there was no publication bias in the meta-analysis. The meta-analysis research results and meta-thematic analysis show the use of learning in education using STEM (Science, Technology, Engineering, Mathematics) (Batdi et al. 2019; Wahono et al. 2020) has a positive effect on academic achievement and skills development. (Batdi et al., 2019). Meanwhile, Wahono et al. (2020) systematically reviewed, and meta-analysis showed that STEM learning in Asia effectively affected students' higher-order thinking skills, student academic achievement, and motivation.

Furthermore, the funnel plot analysis results using the trim and fill method containing closed circles that form symmetrically show no publication bias for each research study or no missing or unpublished research. These results provide information that the difference in learning effectiveness using innovative and conventional models in improving the mathematics problem-solving abilities of junior high school students is free from the potential for publication bias. The same condition is also obtained based on the forest plot before and after using the trim and fill method.

The validity of the differences in innovative and conventional learning effectiveness is valid in improving junior high school students' mathematics problem-solving abilities. The same study results using a random-effects model with the trim and fill method have been carried out by Retnawati & Subarkah (2018), showing no publication bias in identifying scientific learning models capable of improving student learning outcomes. Besides, the research results by Candra & Retnawati (2020) also show no publication bias in looking at the relationship between constructivism learning and civics education learning outcomes.

Conclusion

Research with a meta-analysis approach in identifying biased publications on research studies in seeing the effectiveness of innovation learning on junior high school students' mathematics problem-solving abilities has a procedure stage, including effect size analysis, a heterogeneous research data test grouping, summary effect analysis, and forest plot analysis. The final stage of the funnel plot analysis uses the trim and fill method. The results of forest plot analysis using a random-effects model show that innovative learning is more effective than conventional learning in improving mathematical problem-solving abilities.

Also, this study's results provide information that the students' mathematical test ability increased 95% higher for the experimental group with innovative learning compared to the control group with conventional learning. Furthermore, the funnel plot analysis results using the trim and fill method indicated no publication bias or no missing or unpublished research for each of the research studies used in this study. These results provide information that there are differences in innovative and conventional learning effectiveness in improving junior high school students' mathematics problem-solving abilities. Besides, the validity of the difference in the two lessons' effectiveness is valid in enhancing students' mathematical problem-solving skills.

The contribution of this research is to conduct a meta-analysis approach to identify biased publications by using the trim and fill method in determining the effectiveness of innovative learning on the mathematics problem-solving abilities of junior high school students. The approach involves combining and evaluating descriptive statistics and then reporting the research results based on published and unpublished relevant research study data and discussing and testing the same conceptual research questions and hypotheses. The second contribution provides information to readers related to research studies that have been carried out by grouping them based on measured variables that significantly affect and follow general theory construction and conformity with the research results' expectations. This study's limitation is that grouping research related to measurable variables with numerical grouping information based on res that has been published results in journals without paying attention to the publication.

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