Pegem Journal of Education and Instruction, Vol. 11, No. 4, 2021 (pp. 290-305)

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RESEARCH ARTICLE **WWW.PEGEGOG.NET**

Can Innovative Learning Affect Students' HOTS Achievements?: A Meta-Analysis Study

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Abstract

This study looks at innovative learnings' effect on achieving students' High Order Thinking Skills (HOTS). HOTS is one part of the skills that need to be developed in the 21st Century. This research is a quantitative study with a meta-analysis approach to the mean with random-effects models. Generally, the steps involve formulating research problems meta-analysis to be performed, collecting studies, calculating the effect size, test of heterogeneity, data analysis (summary effect, forest plots, funnel plots, test the potential for publication bias), and concludes. The research sample of 42 research includes international journals and national, international, and nationwide proceedings and a thesis student. The analysis using random models (random-effect model) obtained a mean value of the effect size of aggregation or summary effect amounted to 77.37, standard error weighs the mean 12.36, the upper limit of 53.14, and the lower limit of 101.60. Analysis of the null hypothesis (Ho: actual effect $\boldsymbol{\theta} = \mathbf{0}$) leads to rejecting Ho because the Z value of the summary effect is 77.37 with the one-tailed p-value (0.00) smaller than the α value (0.05). Analysis of publication bias tests from Funnel Plot, Rank Correlation, Regression Method outputs, and "Trim and Fill" shows no potential publication bias regarding conclusions drawn. So the findings made based on the random effect model on the application of innovative learning affect HOTS students achievement (analyzing, evaluating, creating, critical and creative thinking skill aspects) are valid. The implication is that teachers or other practitioners can use innovative learning to improve students' HOTS.

Keywords: Innovative learning, HOTS, meta-analysis

Introduction

Today it is known as a century full of competent challenges both in science and technology. The competency needed in the 21st Century focuses on conceptual knowledge and the skills to apply knowledge and thinking skills. The 21st Century skills one has several definitions (Aljarrah & Khataybeh, 2021). The 21st Century skills is a group of skills that include several skills, including life skills, workforce skills, interpersonal skills, practical skills, and non-cognitive skills (Silva, 2009). On the other hand, the 21st Century skills were defined as the skills that the learner needs to succeed in their professional life through the information age. It was divided into three categories: First: Learning skills and called (4C): Critical thinking, Creativity, Collaboration, and Communication (Stauffer, 2018). Critical and creative thinking are high-level skills (High Order Thinking Skills, HOTS) (Conklin, 2012; King et al., 2010; Krulik & Rudnick, 1999; Presseisen, 1988).

Some experts associate HOTS with a type of thinking skill that each individual can perform. Thinking skills part of HOTS, according to experts, include critical thinking skills and creative thinking (Conklin, 2012; King et al., 2010; Krulik & Rudnick, 1999; Presseisen, 1988), problem-solving (Brookhart, 2010; Presseisen, 1988), logical thinking, reflective, and metacognitive (King et al., 2010), and decision making(Presseisen, 1988). These skills are not foreign terms in the learning process; they have become targets and are part of each subject's learning objectives (Jailani & Retnawati, 2016) which used pretest-posttest experimental non-equivalent control group. Experimental class was a class which was taught by using problem-based learning, while the control class was a class which was taught by using direct instruction. The population of this research was the seventh graders of several Junior High Schools in DI Yogyakarta which have implemented problem based learning. The samples of this research were 515 students of Junior High School students from 10 schools in four districts and one city in Yogyakarta.

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How to cite this article: Saepuzaman D, Retnawati H, Istiyono E, eHaryanto, (2021). Can Innovative Learning Affect Students' HOTS Achievements?: A Meta-Analysis Studys. Pegem Journal of Education and Instruction, Vol. 11, No. 4, 2021, 290-305

Source of support: Nil

Conflict of interest: None.

DOI: 10.47750/pegegog.11.04.28

Received: 26.07.2021

Accepted: 23.09.2021 **Publication:** 01.10.2021

The schools from which the samples were taken were both public and private schools which were selected based on their achievement in the national examination. The schools were selected using stratified random sampling, while the classes were selected randomly. The quantitative data analysis was conducted by using both descriptive and inferential statistic. The results showed that: (1.

In the context of learning in school, the HOTS indicator refers to Bloom's taxonomy put forward by Benjamin S. Bloom in 1956 (Crumb, 1983). When associated with cognitive processes in Bloom's taxonomy, HOTS contrasted with LOTS (Lower Order Thinking Skills). Cognitive process analysis (analysis), synthesis (synthesis), and evaluation (evaluation) were categorized as HOTS, while knowledge (knowledge), understanding (comprehension), and applications (application) were included as LOTS (Fisher, 2010). Still related to HOTS and LOTS' categorization in Bloom's taxonomy, a different opinion was expressed by Thompson (Thompson, 2011), who categorized the analysis, synthesis, and evaluation as HOTS, knowledge, and understanding as LOTS, while the application classified as HOTS or LOTS. Bloom's taxonomy revision by Anderson & Krathwohl (Anderson & Krathwohl, 2001), where learning objectives classification into two dimensions: cognitive processes and knowledge, HOTS in Bloom's taxonomy need to be adjusted. Based on Bloom's taxonomy revisions (Anderson & Krathwohl, 2001), HOTS's dimension includes the process of analyzing (analyze), evaluating (Evaluate), and create (create) (X. Liu, 2014), while the dimensions of knowledge HOTS include conceptual knowledge, procedural knowledge, and metacognitive knowledge.

HOTS is very important for everyone, including students as the next generation. The implication, the implementation of education or learning in the classroom must facilitate students' high-level thinking skills. Of course, achieving this goal requires cooperation, support, and effort from all parties involved, especially teachers. Teachers should create the right and training HOTS on students in both the learning and assessment.

Teachers must be able to plan and implement the learning that can facilitate HOTS students' achievement optimally. The learning carried out must focus on students no longer concentrate on the teacher as is usually the case in the field. Learning that is not, as usual, is done and aims to facilitate students in building their knowledge so that more optimal learning is usually known as the term innovative learning. The use of innovative words in learning is still general. In the context of the learning process can be many learning models that fall into the category of innovative learning, such as instructional learning, learning with a scientific approach (scientific approach), Problem Based Learning (PBL), Learning-Based Autonomy Learner, Scientific Approach, Problem Solving Strategy, contextual learning, inquiry learning, and other learning. In addition to a review of the learning process or model, innovative learning can be view in terms of the media used, such as interactive media, video simulations or animations, the use of electronic teaching materials, or others.

Many studies state that certain learning models can facilitate the improvement of students' HOTS achievement. Problem-based learning can facilitate the achievement of students' HOTS (Arends & Kilcher, 2010; Guedri, 2001). The inquiry learning model has a positive effect on students' higher order thinking skills (Hendryarto, 2013; Smart & Marshall, 2013). These studies are very limited in their applicability only to certain samples or characteristics of students. Thorough research that compiles all learning-related outcomes that are able to facilitate student HOTS is still limited.In this study, the focus is on studies related to innovative learning on HOTS student achievement. This study uses the meta-analysis approach, a part of quantitative research using secondary data from studies that already exist and have been used by other researchers who carried out systematically and quantitatively to get accurate conclusions (Retnawati, 2018). Thus, in this study, the initial stages are collecting material in the form of research -Research relevant to the achievement of HOTS innovative learning in students of existing research publications covering international journals and national, proceedings of international and national and theses dissertations of students. The next step is analysis in the meta-analysis until an accurate (valid) conclusion.

Method

Research Design

This research is a quantitative study using a meta-analysis approach to analyze empirical studies conducted by previous researchers regarding the effect of applying innovative learning in students' HOTS achievements, quantitative research results, research results in comparable form, for example, in this case, on a mean. The study results are used as material to calculate the effect size, which compiles the aggregate. The meta-analysis was used to test constructs and relationships compared. This meta-analysis is a particular research method for combining studies that can measure their effect size. Value effect size is used to achieve the standard value in evaluating independent studies' results with meta-analysis (Turgut & Turgut, 2018). The effect size value also provides a standardized independent study result and is assessed based on the same criteria (Turgut & Turgut, 2018). The studies that are collected henceforth were coded based on specific criteria. Encoding is the process of extracting data from the individual studies to obtain data that the air responds late with the data analyzed (Çoğaltay & Karadağ, 2015; Koza Çiftçi & Yıldız, 2019).

Furthermore, meta-analysis research using statistical analysis in research and interpreting findings (Pigott, 2012). In this research, the meta-analysis used is a meta-analysis with the mean. So the determination of the effect size is analyzed using the mean and requires a mean value and standard deviation.

Population and Sample/ Study Group/Participants

The research sample of 42 research includes international journals and national, international, and nationwide proceedings and a thesis student whose work is related to implementing innovative teaching-learning in HOTS student achievement. Reference selection is based on the validity of the data and the availability of the required information. Of all the references used, the application of the learning model is generally able to facilitate the improvement of students' HOTS achievement with specific characteristics of students employed as research samples. This research is to see a comprehensive picture of the application of innovative learning models in facilitating students' HOTS.

Data Collection Tools

The selection of research samples so that 42 research results were taken related to the application of innovative learning in the achievement of students' HOTS were carried out by considering the validity data and the availability of the required information. The computer program JASP 0.11.1.0 was used (free from the page: https://jasp-stats.org/previous-versions/). With the help of JASP, summary effects, forest plots and funnel plots will be obtained. The following analysis step is to interpret the output summary effect, forest plot and funnel plot. To detect the existence of publication bias in terms of Funnel Plot, Rank Correlation and Regression Method, and Trim and Fill.

Data Collection

The data in this study are secondary. This secondary data is in the form of studies or relevant research results as material for meta-analysis. Research data collection is done by searching for online international journals, a thesis, or a dissertation. The priority of the search focuses on research published in reputable international journals. But some studies do not include standard deviations as data needed in a meta-analysis. Other investigations are through university repositories or libraries that provide theses and dissertations as research students and supervisors. Even though the final project does not include the mean and standard deviation, it can be determined from the original score attached. From this search, 42 studies were relevant to the criteria.

From 42 research search results, the next step is to do the coding. This study's coding is researcher/study, year, independent variable (the type of innovative learning), dependent variable (HOTS), sample size, mean achievement, and standard deviation. This stage is part of the analysis before the statistical analysis process.

Data Analysis

Determination of standard effect sizes (transformed)

After obtaining mean data and standard deviations for each study, the next step is to transform the mean into the same scale, resulting in each study's effect size. In this study, the range of values from 1 to 100, the transformation carried out refers to a scale of 1-100. This transformation is to standardize the effect size of each study. Standard effect sizes are used to compare independent group means, which are considered comparable for each study of each of the two variables (Freeman et al., 1986; Koza Çiftçi & Yıldız, 2019)and (ii.

Heterogeneity Test

After calculating the effect size, what needs to calculate the aggregation effect size, which is also called the summary effect, is conducting a meta-analysis. In the aggregate calculation, there are two models to choose from, namely the fixed model (fixed-effect model) and models random (random effect model) (Retnawati, Apino, et al., 2018). To determined the models, the heterogeneity test is needed. Heterogeneity test using the following equation $Q = \sum w_i ES_i^2 - \frac{(\sum w_i ES_i)^2}{\sum w_i}$; with the criteria for decision making statistically, Ho is rejected if the chi-square table. Ho here states that the effect size ($\overline{ES}$) between homogeneous studies (Retnawati, Apino, et al., 2018).

Final Data analysis

Data analysis included a summary effect, forest plot, funnel plot, and publication bias. Summary effect ($\overline{ES}$) can get manually or computer-assisted. Manually using equations $\overline{ES} = \frac{\sum w_i ES_i}{\sum w_i}$ (Retnawati, Apino, et al., 2018), while computer programs using the JASP 0.11.1.0 program (free obtained from https://jasp-stats.org/previous-versions/). Aided by JASP will get a summary effect, forest plot, and funnel plot. The subsequent analysis is the interpretation output summary effect, forest plots, and funnel plots. To detect the publication bias in the Funnel plot, Rank Correlation and Regression Method, and Trim and Fill.

Findings

Of the 42 studies deemed relevant to the search results, various characteristics started from the year, sample size, mean values, innovative learning models (independent variables), and HOTS's definition (dependent variable). In general, research results are determined by researchers as samples presented in Table 1.

0Based on the table above, there are 42 relevant studies. If we look at the mean value, we will see a slightly different mean value, and this is because of the different scales used. The next step is to transform the mean into the same scale, and the result is an effect size of each study. Because the most common is a score range of 1 to 100, other scores convert to a scale of 1-100. The standard deviation is also transformed to calculate *SE* and *w*. The results are presented in Table 2.

In conducting a meta-analysis, after calculating the effect size, what needs to be done is to calculate the aggregation effect size, also called the summary effect. In the aggregate calculation, there are two models to choose from, namely the fixed model (fixed-effect model) and models random (random effect model) (Retnawati, Apino, et al., 2018). To determine which model fit, using the heterogeneity test—the

Table 1: Results of relevant research (study) findings

Study	*Research er*	*N*	*Mean*	*Independent Variable (Innovative Learning)*	*Dependent Variable(High Order Thinking Skill, HOTS)*
Study_1	(S. Liu et al., 2018)	44	255.11	Constructivism	Problem Solving and Critical Thinking
Study_2	(Salam & Miriam, 2016)	34	78.20	Learner Autonomy based learning	Analyzing (C4), evaluating (C5), and creating (C6)
Study_3	(Folly Eldy & Sulaiman, 2013)	28	44.02	Integrated PBL Approach	Critical Thinking and Creative-Critical Thinking
Study_4	(Khoiriah & Jalmo, 2020)	29	81.38	Student Worksheets Based On Discovery Learning	Analysis (C4), evaluate (C5), and creating (C6)
Study_5	(Luthfiyah et al., 2019)	30	77.18	Problem Based Learning (PBL) learning model in curriculum 2013 using the development of teaching materials	analytical and creative
Study_6	(Utomo et al., 2019)	32	76.94	Problem Based Learning with a Scientific Approach	Analyzing (C4), evaluating (C5), and creating (C6)
Study_7	(Saputri et al., 2019)	32	82.61	Stimulating Higher Order Thinking Skills Model	Critical Thinking
Study_8	(Malik et al., 2017)	20	7.40	HOT lab design	creative thinking skills
Study_9	(Ambarita et al., 2019)	338	84.60	Group Investigation Based on Hands-on Activities	Analysis, evaluation, and creation; Logical reasoning Decision and critical thinking; Problem-solving; Creativity and creative thinking
Study_10	Tambunan	138	75.60	Problem Solving Strategy and the Scientific Approach	communication, creativity, problem-solving and mathematical reasoning
Study_11	(Hidayati & Retnawati, 2018)	30	51.33	Problem Based Learning and scientific approach	Analyzing (C4), evaluating (C5), and creating (C6)
Study_12	(Saregar et al., 2016)	26	68.30	CUPS Learning	analyzing (C4), evaluating (C5), and creating (C6)
Study_13	(Fauziah, 2013)	31	87.62	Online problem-based learning	Creativity and Critical Thinking
Study_14	(Ramadhan, 2019)	34	83.61	Physics Comic with Android	analyzing (C4), evaluating (C5), and creating (C6)
Study_15	(Dasilva & Suparno, 2019)	106	75.14	Interactive Physics Mobile Learning Media (IPMLM) with Scaffolding learning	analyzing (C4), evaluating (C5), and creating (C6)
Study_16	(Sekarini, 2019)	33	82.42	Contextual based Science Outdoor Learning	analyzing (C4), evaluating (C5), and creating (C6)

Study	*Researcher*	*N*	*Mean*	*Independent Variable (Innovative Learning)*	*Dependent Variable(High Order Thinking Skill, HOTS)*
Study_17	(Yusuf, 2019)	19	68.26	Higher Order Thinking Skills Learning Model	Critical thinking, creative thinking, and problem-solving
Study_18	(Ferty & Suparno, 2019)	90	75.34	Android Based Interactive Physics Mobile Learning Media	analyzing (C4), evaluating (C5), and creating (C6)
Study_19	(Haryanto & Arty, 2019)	30	15.53	Science video animation based Contextual Teaching And Learning (CTL)	analyzing (C4), evaluating (C5), and creating (C6)
Study_20	(Puspaningtyas, 2019)	18	83.61	Enhancing thinking skill strategy	analyzing (C4), evaluating (C5), and creating (C6)
Study_21	(Arisandi & Sutrisno, 2019)	32	70.66	Analogy lerarning	analyzing (C4), evaluating (C5), and creating (C6)
Study_22	(Suleman & Sugijarto, 2019)	29	76.45	Three Dimension Visualization with Virtual Reality (3D-VR)	Critical thinking skill
Study_23	(Ariansyah & Soenarto, 2019)	21	56.90	Contextual Teaching and Learning (CTL)	Critical thinking skill
Study_24	(Alandia & Suparwoto, 2019)	61	92.10	Problem Based Learning With Web in Physics Learning	Critical thinking skill
Study_25	(Kurnia & Retnowati, 2019)	25	3.52	Erroneous worked example and grouping strategy	analyzing (C4), evaluating (C5), and creating (C6)
Study_26	(Baskoro, 2019)	17	86.76	Variation Theory in mathematic learning	analyzing (C4), evaluating (C5), and creating (C6)
Study_27	(Wardani, 2019)	64	83.48	Guided inquiry Learning	Critical thinking skill
Study_28	(Putri & Ghufron, 2019)	86	79.36	The Power Of Two Strategy	Critical thinking skill
Study_29	(Maghfiroh & Mulyani, 2019)	35	86.43	HOTS based Problem Based Learning	Critical thinking skill
Study_30	(Ferty & Suparno, 2019)	90	69.50	Android-based Interactive Physics Mobile Learning Media (IPMLM)	analyzing (C4), evaluating (C5), and creating (C6)
Study_31	(Widiyowati, 2014)	42	62.74	Contextual Learning Model	Critical thinking skill
Study_32	(Rahayu & Utaminingsih, 2017)	50	4.87	Effective Questioning strategy	analyzing (C4), evaluating (C5), and creating (C6
Study_33	(Redhana, 2013)	70	24.93	Problem-based Learning and Socratic question	Critical thinking skill
Study_34	(Suarsana, 2013)	34	27.60	Problem Solving based E-module	Critical thinking skill
Study_35	(Mayasari & Adawiyah, 2016)	24	78.20	Problem Based Learning	analyzing (C4), evaluating (C5), and creating (C6)
Study_36	J (Hendryarto, 2013)	28	85.71	Inquiry-Based Learning	analyzing (C4), evaluating (C5), and creating (C6)
Study_37	(Erny et al., 2017)	37	84.46	Scientific Approach	Critical and creative thinking
Study_38	(Nyoman Setiawan, 2015)	42	59.21	Science Contextual Learning integrated with higher-order thinking skill	Critical and creative thinking
Study_39	(Rosida et al., 2017)	30	62.85	Interactive e-book based learning	Critical thinking skill
Study_40	(Najib, 2015)	36	78.34	Phet Simulation in inquiry laboratory learning	analyzing (C4), evaluating (C5), and creating (C6)
Study_41	(Azis Nur, 2016)	14	62.50	Problem Based Learning	analyzing (C4), evaluating (C5), and creating (C6)
Study_42	(Agustina et al., 2020)	42	62.74	Contextual teaching and learning	Critical thinking skill

Table 2: Tabulation of transformed data and data for data analysis

Study	*n*	*mean*	*s*	*min*	*max*	*ES (transf)*	*s (transf)*	*SE*
Study_1	44	255.11	19.16	0	300	85.04	6.39	0.96
Study_2	34	78.20	9.40	0	100	78.20	9.40	1.61
Study_3	28	44.02	11.40	0	60	73.37	19.00	3.59
Study_4	29	81.38	6.53	0	100	81.38	6.53	1.21
Study_5	30	77.18	9.37	0	100	77.18	9.37	1.71
Study_6	32	76.94	15.67	0	100	76.94	15.67	2.77
Study_7	32	82.61	8.07	0	100	82.61	8.07	1.43
Study_8	20	7.40	0.60	0	10	74.00	6.00	1.34
Study_9	338	84.60	6.58	0	100	84.60	6.58	0.36
Study_10	138	75.60	6.85	0	100	75.60	6.85	0.58
Study_11	30	51.33	7.97	0	60	85.55	13.28	2.43
Study_12	26	68.30	11.90	0	100	68.30	11.90	2.33
Study_13	31	87.62	20.28	0	100	87.62	20.28	3.64
Study_14	34	83.61	5.80	0	100	83.61	5.80	0.99
Study_15	106	75.14	8.03	0	100	75.14	8.03	0.78
Study_16	33	82.42	7.19	0	100	82.42	7.19	1.25
Study_17	19	68.26	4.62	0	100	68.26	4.62	1.06
Study_18	90	75.34	4.56	0	100	75.34	4.56	0.48
Study_19	30	15.53	1.69	0	20	77.65	8.45	1.54
Study_20	18	83.61	6.59	0	100	83.61	6.59	1.55
Study_21	32	70.66	14.10	0	100	70.66	14.10	2.49
Study_22	29	76.45	7.09	0	100	76.45	7.09	1.32
Study_23	21	56.90	5.90	0	64	88.91	9.22	2.01
Study_24	61	92.10	4.92	0	100	92.10	4.92	0.63
Study_25	25	3.52	0.78	0	5	70.40	15.60	3.12
Study_26	17	86.76	4.20	0	100	86.76	4.20	1.02
Study_27	64	83.48	13.42	0	100	83.48	13.42	1.68
Study_28	86	79.36	8.97	0	100	79.36	8.97	0.97
Study_29	35	86.43	5.74	0	100	86.43	5.74	0.97
Study_30	90	69.50	5.50	0	80	86.88	6.88	0.72
Study_31	42	62.74	11.33	0	100	62.74	11.33	1.75
Study_32	50	4.87	1.15	0	5	97.40	23.00	3.25
Study_33	70	24.93	3.84	0	40	62.33	9.60	1.15
Study_34	34	27.60	11.30	0	50	55.20	22.60	3.88
Study_35	24	78.20	12.04	0	100	78.20	12.04	2.46
Study_36	28	85.71	5.70	0	100	85.71	5.70	1.08
Study_37	37	84.46	8.66	0	100	84.46	8.66	1.42
Study_38	42	59.21	6.28	0	100	59.21	6.28	0.97
Study_39	30	62.85	7.71	0	100	62.85	7.71	1.41
Study_40	36	78.34	6.17	0	100	78.34	6.17	1.03
Study_41	14	62.50	14.24	0	100	62.50	14.24	3.81
Study_42	42	62.74	11.33	0	100	62.74	11.33	1.75

Table 3: Tabulation of Heterogeneity Test data

Study	ES_i	SE_i	w_i	${w_i}^2$	$w_i.ES_i$	$w_i.{ES_i}^2$	$(w_i.ES_i)^2$
Study_1	85.04	0.96	1.085	1.177	92.274	7847.007	8514.547
Study_2	78.20	1.61	0.386	0.149	30.169	2359.184	910.144
Study_3	73.37	3.59	0.078	0.006	5.693	417.684	32.409
Study_4	81.38	1.21	0.683	0.467	55.584	4523.396	3089.540
Study_5	77.18	1.71	0.342	0.117	26.394	2037.123	696.667
Study_6	76.94	2.77	0.130	0.017	10.027	771.516	100.551
Study_7	82.61	1.43	0.489	0.239	40.398	3337.284	1632.004
Study_8	74.00	1.34	0.557	0.310	41.212	3049.677	1698.417
Study_9	84.60	0.36	7.716	59.537	652.778	55225.000	426118.827
Study_10	75.60	0.58	2.973	8.837	224.732	16989.774	50504.679
Study_11	85.55	2.43	0.169	0.029	14.488	1239.446	209.901
Study_12	68.30	2.33	0.184	0.034	12.581	859.270	158.277
Study_13	87.62	3.64	0.075	0.006	6.613	579.434	43.732
Study_14	83.61	0.99	1.020	1.041	85.308	7132.570	7277.390
Study_15	75.14	0.78	1.644	2.702	123.504	9280.111	15253.306
Study_16	82.42	1.25	0.640	0.410	52.749	4347.556	2782.436
Study_17	68.26	1.06	0.890	0.792	60.751	4146.874	3690.703
Study_18	75.34	0.48	4.340	18.838	326.997	24635.918	106926.729
Study_19	77.65	1.54	0.422	0.178	32.742	2542.386	1072.013
Study_20	83.61	1.55	0.416	0.173	34.801	2909.732	1211.127
Study_21	70.66	2.49	0.161	0.026	11.397	805.283	129.882
Study_22	76.45	1.32	0.574	0.329	43.876	3354.340	1925.126
Study_23	88.91	2.01	0.248	0.061	22.007	1956.632	484.303
Study_24	92.10	0.63	2.520	6.348	232.048	21371.655	53846.448
Study_25	70.40	3.12	0.103	0.011	7.232	509.139	52.303
Study_26	86.76	1.02	0.961	0.924	83.391	7235.003	6954.059
Study_27	83.48	1.68	0.354	0.126	29.578	2469.143	874.838
Study_28	79.36	0.97	1.063	1.130	84.345	6693.601	7114.041
Study_29	86.43	0.97	1.063	1.130	91.859	7939.361	8438.050
Study_30	86.88	0.72	1.929	3.721	167.593	14560.444	28087.277
Study_31	62.74	1.75	0.327	0.107	20.487	1285.325	419.698
Study_32	97.40	3.25	0.095	0.009	9.221	898.155	85.032
Study_33	62.33	1.15	0.756	0.572	47.130	2937.640	2221.278
Study_34	55.20	3.88	0.066	0.004	3.667	202.402	13.445
Study_35	78.20	2.46	0.165	0.027	12.922	1010.516	166.983
Study_36	85.71	1.08	0.857	0.735	73.483	6298.186	5399.679
Study_37	84.46	1.42	0.496	0.246	41.887	3537.736	1754.481
Study_38	59.21	0.97	1.063	1.130	62.929	3726.033	3960.073
Study_39	62.85	1.41	0.503	0.253	31.613	1986.883	999.388
Study_40	78.34	1.03	0.943	0.888	73.843	5784.858	5452.783
Study_41	62.50	3.81	0.069	0.005	4.306	269.098	18.538
Study_42	62.74	1.75	0.327	0.107	20.487	1285.325	419.698
Sum	3249.53	70.5	38.88077	112.945	3105.093	250347.7	760740.8

heterogeneity test using the following equation (Retnawati, Apino, et al., 2018).

$$Q = \sum w_i\, ES_i^{\,2} - \frac{(\sum w_i ES_i)^2}{\sum w_i}$$

With the criteria for decision making statistically, Ho rejected if the chi-square table. The Ho here states that the effect size ($\overline{ES}$) between homogeneous Studies.

For this purpose, the analysis is done by extending the data as presented in table 3.

By using the values in table 3, the values are obtained

$$Q = \sum w_i\, ES_i^{\,2} - \frac{(\sum w_i ES_i)^2}{\sum w_i} = 250347.7 - \frac{760740.8}{38.88} = 230781.32$$

Because the value is too large compared to the value of the chi-square table ($\mathcal{X}^2$ = 56,94), then Ho is rejected so that it can be proved that the effect of size between heterogeneous studies. Because the effect size is heterogeneous, the fixed (fixed-effect model) can not be used. The recommended model is random (random effect model).

For analysis with a random model, first, estimate C and know the square

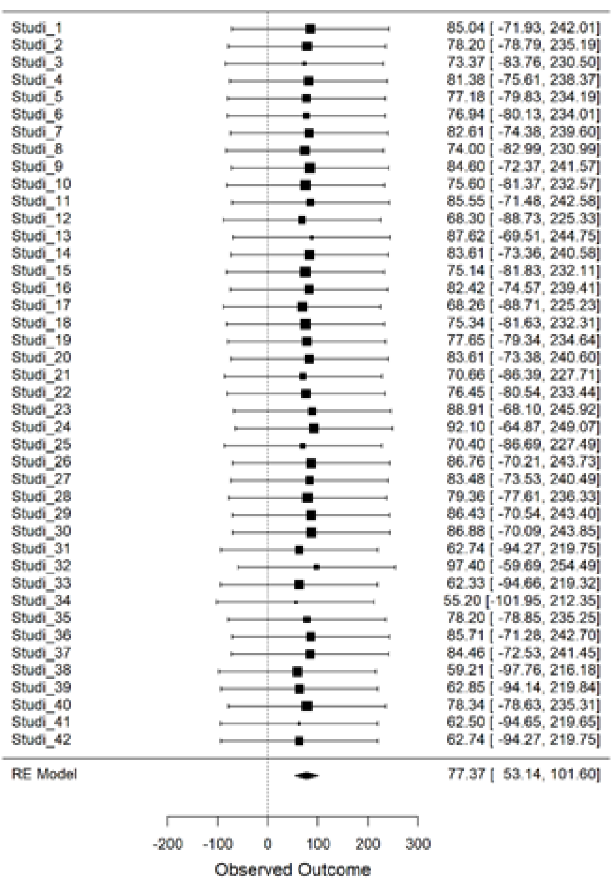

Figure 1: Forest Plot Summary Effect results with a random model

$$C = \sum w_i - \frac{\sum w_i^{\,2}}{\sum w_i} = 38.88 - \frac{112.945}{38.88} = 35.98$$

$$\tau^2 = \frac{Q - df}{C} = \frac{230781.32 - 41}{35.98} = 6414.044$$

By using tau squared (τ^2), the new variance and weighting can be determined. The complete calculation is presented in table 4. The data in table 4 can be determined the value of the mean effect size of aggregation (effect size aggregates) or summary effect or mean weighted at 77.37 with a standard error of the mean weighted random models for 12.36. So that at the 95% significance level, will obtain an upper and lower limit of 53.14 to 101.60. In general, these values can also be seen from the forest plot, as presented in Figure 1. Based on the forest plot in Figure 1, the summary effect position appears to be almost the same or close to each study's effect size. These conditions show the consistency of forty-two studies' effect size greatly contributes to the value of the summary effect.

Moreover, the forest plot can also be viewed as relative weight studies towards the total. It can be seen from the box area for each study that shows each study's weight (Retnawati, 2014). It appears from the forest plot of figure 1, from forty-two Studies obtained the highest relative weight of 2.382 % of the total relative weight that is almost owned by more than 50% of the entire study. While the relative weight lower was owned by the 34 studies, which only amounted to 2.377 % of the relative weight in total.

The next analysis calculates the value of Z * and tests the hypothesis related to the significance of the summary effect value. The values Z * to test the null hypothesis (H 0: true effect θ = **0**) using the equation; with p - $value$ one-tailed test: $p*$ = 1 - Φ (± | $Z*$ |) and p - $value$ two-tailed test: $p*$ = 2 [1 - Φ (| $Z*$ |)], where Φ (| $Z*$ |) standard cumulative normal distribution (standard normal cumulative distribution). Φ (| $Z*$ |) can be calculated with MS. Excel with the function "= NORMSDIST (Z *)." By using this analysis, the value and value of Φ (| $Z*$ |) = Φ (6.26) = 1 will be obtained p - $value$ one-tailed test: $p*$ = 0.00 and p - $value$ two-tailed test: $p*$ = 0.

Based on the random-effect model calculation results, a summary effect of 77.37 is obtained with a 95% confidence interval ranging from 53.14 to 101.60. While the results of testing the null hypothesis (H 0: true effect θ = **0**) leads to a decision rejecting Ho. Because the value Z of summary effect amounted to 77.37 with a p-value one-tailed test (0, 00) is smaller than the value of α (0.05) and the two-tailed test (0, 00) p-value is also smaller than α (0.05). The conclusion d ap at drawn by the random-effect model is that innovative applied learning can improve student achievement HOTS.

Publication bias refers to the possibility of finding research that accepts a null hypothesis (absence of statistically significant effects) or negatives (the effect is significant but in the opposite direction to general or expected construction of the theory). Still, it tends to be unpublished compared to research results that show the effect positive (the impact is significant and by the general or expected construction of the theory). Studies with statistically significant results are more likely to be found in published literature than studies that report no statistically significant effects; about 61 to 68

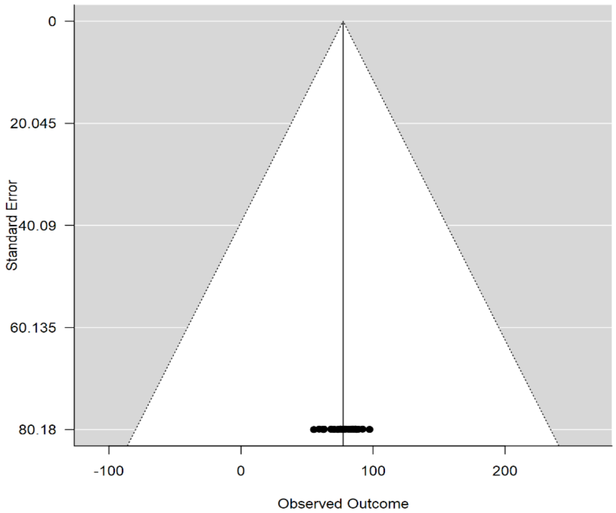

Figure 2: Funnel Plot

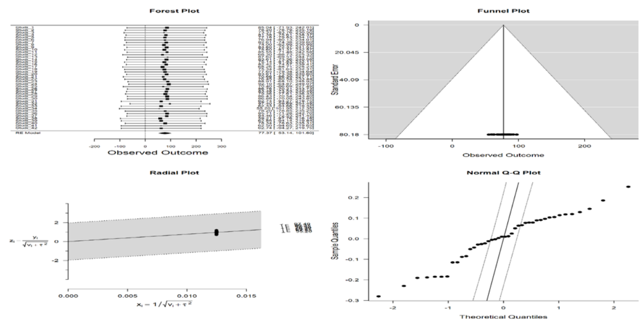

Figure 3: Funnel Plot with Trim and Fill methods

Table 3: Rank Correlation and Regression Results from Funnel Plot

Metode Rank Correlation		*Metode Regression*	
p-value	*Rank Correlation*	*p-value*	*Regression Coeficient*
0,109	-0.186	0.852	-0.186

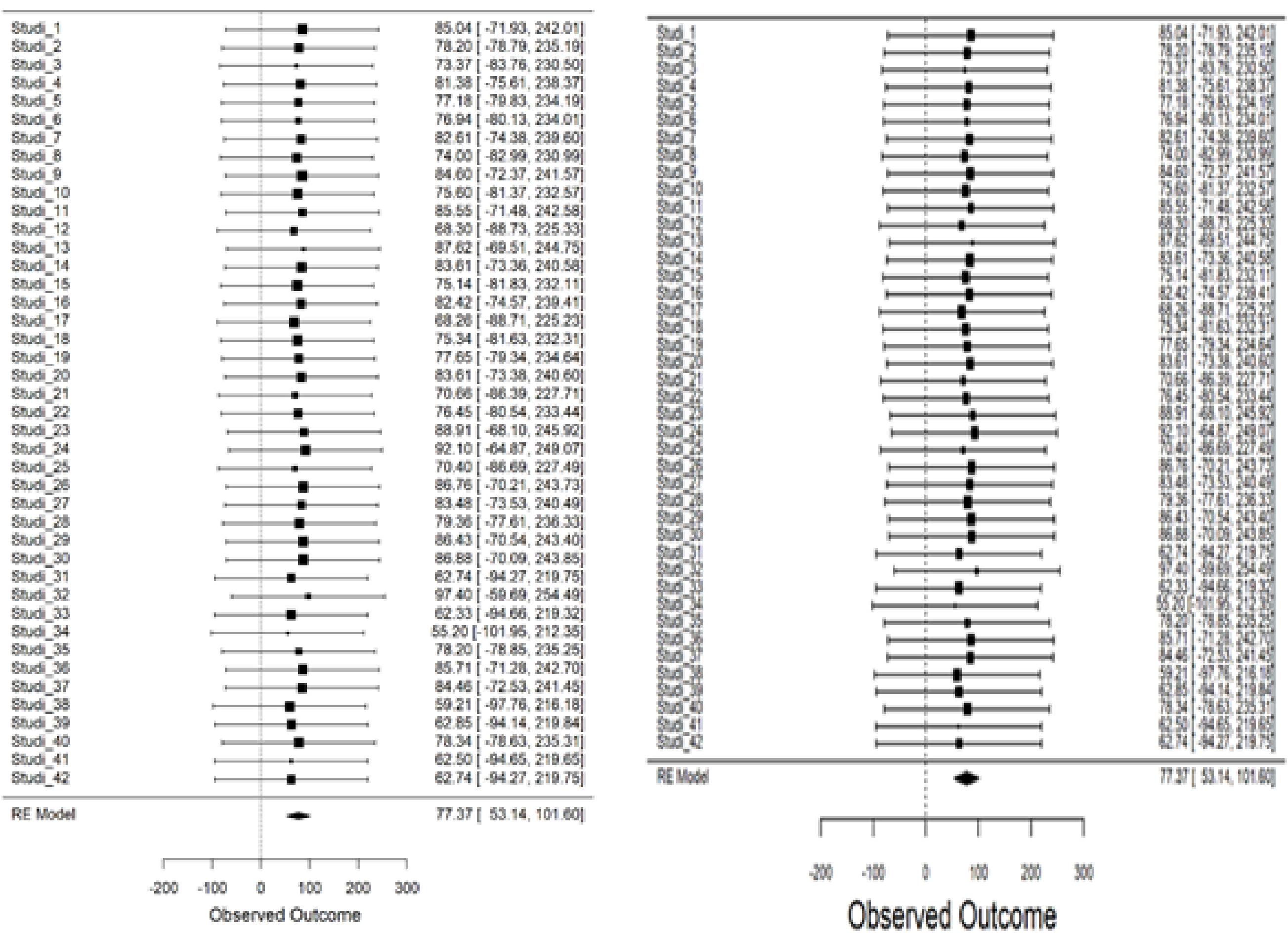

Figure 4: (a) Forest Plot Before and (b) Forest Plot After Using the Trim and Fill Method

Figure 4: (a) Forest Plot Before and (b) Forest Plot After Using

Table 4: New variance and weighting

Study	ES_i	SE_i	V^*	SE^*	wi^*	$wi^*. ES_i$
Study_1	85.04	0.96	6414.97	80.09	0.000156	0.013257
Study_2	78.20	1.61	6416.64	80.10	0.000156	0.012187
Study_3	73.37	3.59	6426.93	80.17	0.000156	0.011416
Study_4	81.38	1.21	6415.51	80.10	0.000156	0.012685
Study_5	77.18	1.71	6416.97	80.11	0.000156	0.012027
Study_6	76.94	2.77	6421.72	80.14	0.000156	0.011981
Study_7	82.61	1.43	6416.09	80.10	0.000156	0.012875
Study_8	74.00	1.34	6415.84	80.10	0.000156	0.011534
Study_9	84.60	0.36	6414.17	80.09	0.000156	0.01319
Study_10	75.60	0.58	6414.38	80.09	0.000156	0.011786
Study_11	85.55	2.43	6419.95	80.12	0.000156	0.013326
Study_12	68.30	2.33	6419.47	80.12	0.000156	0.01064
Study_13	87.62	3.64	6427.29	80.17	0.000156	0.013632
Study_14	83.61	0.99	6415.02	80.09	0.000156	0.013033
Study_15	75.14	0.78	6414.65	80.09	0.000156	0.011714
Study_16	82.42	1.25	6415.61	80.10	0.000156	0.012847
Study_17	68.26	1.06	6415.17	80.09	0.000156	0.01064
Study_18	75.34	0.48	6414.27	80.09	0.000156	0.011746
Study_19	77.65	1.54	6416.42	80.10	0.000156	0.012102
Study_20	83.61	1.55	6416.45	80.10	0.000156	0.013031
Study_21	70.66	2.49	6420.24	80.13	0.000156	0.011006
Study_22	76.45	1.32	6415.79	80.10	0.000156	0.011916
Study_23	88.91	2.01	6418.08	80.11	0.000156	0.013853
Study_24	92.10	0.63	6414.44	80.09	0.000156	0.014358
Study_25	70.40	3.12	6423.78	80.15	0.000156	0.010959
Study_26	86.76	1.02	6415.08	80.09	0.000156	0.013524
Study_27	83.48	1.68	6416.87	80.11	0.000156	0.013009
Study_28	79.36	0.97	6414.98	80.09	0.000156	0.012371
Study_29	86.43	0.97	6414.98	80.09	0.000156	0.013473
Study_30	86.88	0.72	6414.56	80.09	0.000156	0.013544
Study_31	62.74	1.75	6417.11	80.11	0.000156	0.009777
Study_32	97.40	3.25	6424.61	80.15	0.000156	0.01516
Study_33	62.33	1.15	6415.37	80.10	0.000156	0.009716
Study_34	55.20	3.88	6429.10	80.18	0.000156	0.008586
Study_35	78.20	2.46	6420.10	80.13	0.000156	0.012181
Study_36	85.71	1.08	6415.21	80.10	0.000156	0.01336
Study_37	84.46	1.42	6416.06	80.10	0.000156	0.013164
Study_38	59.21	0.97	6414.98	80.09	0.000156	0.00923
Study_39	62.85	1.41	6416.03	80.10	0.000156	0.009796
Study_40	78.34	1.03	6415.10	80.09	0.000156	0.012212
Study_41	62.50	3.81	6428.56	80.18	0.000156	0.009722
Study_42	62.74	1.75	6417.11	80.11	0.000156	0.009777
sum	3086.29	67.93	256714.1	3204.46	0.006233	0.4809

per cent are likely to occur (Dickersin et al., 1987). To detect the publication bias can be viewed from the Funnel Plot, Rank Correlation and Regression Method, and Trim and Fill.

Funnel Plot

If there is no publication bias, the research will be distributed symmetrically about the summary effect (M) because the sampling error is random. Conversely, suppose there is a publication bias. In that case, the research will not follow the expected model (asymmetric, some research is lost in the middle, and more research is lost at the bottom) (Retnawati, Apino, et al., 2018). The resulting output Jasp software obtained funnel plot for analysis of meta is presented in Figure 2.

Figure 2 is a funnel plot with a random model showing that the forty-two samples sampled in the meta-analysis are small sample sizes. If you pay close attention, in general, the whole study is symmetrically distributed. It can be interpreted that there is no potential for publication bias related to conclusions drawn.

Rank Correlation and Regression Method

The rank correlation and regression method is the development of statistical tests of the funnel plot. Output for Rank correlation and regression method presented in Tabel 3.

Table 3 shows that the p-value of the two methods (rank correlation and regression) is greater than the value of α (0.05). It can be interpreted that the funnel plot formed by this random model is symmetrical, or in other words, there is no evidence of publication bias. Negative rank correlation (-0.186) indicates that studies with large sample sizes are not included in the meta-analysis research sample, more dominant studies with small sample sizes. The regression coefficient is the coefficient of the estimated bias (-0.186). Overall it can be interpreted that we do not have enough strength to detect bias using rank correlation and regression methods.

Trim and Fill

Trim and Fill use an iterative procedure to remove the most extreme small research from the funnel plot's positive side, recalculating the effect size on each iteration until the funnel plot is symmetrical. In theory, this will produce an unbiased effect size estimate. In addition to this trim, the effect size is adjusted, reduces the effect variance, and results in a narrower confidence interval. Therefore, it is necessary to add back original research into the analysis. This fill has no impact on point estimation but improves variance (Duval & Tweedie, 2000).

A computer program that can combine Trim and Fill (Trim and Fill) can create a funnel plot that includes research observed with missing research (not published). Researchers can see how the effect size shifts when missing (not published) studies are included in the analysis. If the change is small, other people can immediately trust our conclusions (the reported results are valid). The funnel plot of the Trim and Fill method for this study is presented in Figure 3. Figure 3 was obtained from the JASP software output version 0.11.1.0 using the Trim and Fill method. In Figure 3, there is no visible circle in the funnel plot of the random effect model. It can mean that there is no or not found missing (unpublished) research related to this study.

Apart from the funnel plot, it can also be viewed from the forest plot. If the research indicates publication bias, then the summary effect of the random-effect model will shift or drop from the previous summary effect (summary effect before being analyzed by the Trim-Fill method), and the number of research samples will increase by itself (label: filled 1, filled 2, ... and filled n). Based on this analysis, it can be seen that the conclusions regarding the application of innovative learning towards the achievement of students HOTS are free of potential publication bias. The forest plot's appearance also strengthens before and after using the Trim and Fill method, as presented in **Figure 4**. **Figure 4** shows that the fixed-effect model's summary effect before using the Trim and Fill method (original) is the same as after being subjected to Trim and Fill's method. This condition indicates that the conclusions based on the random effect model on innovative learning in achieving HOTS students are valid.

Discussion

Based on the explanation of the study results, it can be obtained based on a meta-analysis that innovative learning has a strong influence on the achievement of HOTS students. This influence can be seen from the value of the summary effect or mean effect size with a random model of 77.37 and a Z value of 6.26, which statistically proves that the effect is significant. This significant influence can not be separated from the applied innovative learning. A funnel plot with a random model shows that the forty-two samples sampled in a meta-analysis are small sample sizes and symmetrically distributed. It can be interpreted that there is no potential for publication bias related to the conclusions drawn. This condition is also reinforced by the forest plot's views, which showed the fixed-effect models' summary effect before using the Trim and Fill (original) together with a summary effect after having been subjected to method Trim and Fill. The conclusion that can be drawn based on the random-effect model is that innovative learning that is applied can improve HOTS students' achievement. This conclusion is free from publication bias, so it is valid (Ateş, 2021; Candra & Retnawati, 2020)

Innovative learning is meant active learning and student-centred learning that is deemed appropriate to training HOTS students (Akyol & Garrison, 2011; Limbach & Waugh, 2010;

Retnawati, Djidu, et al., 2018). Active learning and student-centered learning such as problem-based learning (PBL) (Mohd Zin Mokhtar et al., 2013), project-based learning (PjBL) (Vidergor & Krupnik-Gottlieb, 2015)making meaning and transferring in very short times. Problem based learning and project based learning facilitate meaningful learning, development of complex skills and independent learner proficiency (For example: Tarhan 2007; Hmelo-Silver, 2004, learning discovery, and learning-based inquiry (Orlich et al., 2010), or other learning models that use contextual problems are some examples of strategies of innovative learning to train the right HOTS students. Besides, Protheroe (Goethals, 2013) and Miri, David, and Uri (Miri et al., 2007)within the framework of science education. Within a pre-, post-, and post-post experimental design, high school students, were divided into three research groups. The experimental group (n = 57 mentioned that group discussions and solving complex and interdisciplinary problems in the learning process were also important activities to train HOTS students. Innovative learning is very thick with this activity (Lehmann et al., 2008) where their boundaries are often difficult to identify, and where societal rather than technical issues play increasingly bigger roles, problems cannot be solved by applying a technical solution alone. It thus becomes important for engineers to be skilled not only in terms of their particular technical field but also their ability to identify non-technical aspects of problems, the interaction between these aspects and possible solutions. Introducing and integrating these aspects into engineering education is certainly not an easy task and requires innovative approaches. In this article, focus is placed on the so-called Aalborg Model, a problem-oriented and project-based learning paradigm utilised at Aalborg University (Denmark.

This study's results can also provide empirical evidence and contribute to alternative learning consistent with that recommended in implementing the 2013 curriculum. As is well known, one of the components that become a curriculum review is high-level thinking skills (HOTS). HOTS is an essential element for solving new problems in the 21st Century (Brookhart, 2010; Moseley et al., 2005; Thompson, 2008). HOTS also plays an essential role in applying, connecting, or manipulating prior knowledge to effectively solve new problems (Thomas & Thorne, 2009). In line with this, there are two main reasons HOTS is important for students: students must succeed at school and make a positive contribution to society (Conklin, 2012). Therefore, HOTS is very important in the learning process so that students can contribute to the community. In the revised Bloom taxonomy, HOTS is defined as a slice between the top three levels of ability in the cognitive dimension (analyzing, evaluating, creating) and three levels of the dimension of knowledge (conceptual, procedural, metacognitive) (Anderson & Krathwohl, 2001; Thompson, 2008). Besides, creative thinking and critical thinking skills are included in higher-order thinking skills (HOTS) (Miri et al., 2007; Moseley et al., 2005)within the framework of science education. Within a pre-, post-, and post-post experimental design, high school students, were divided into three research groups. The experimental group (n = 57.

HOTS's importance is no exception for students in school, making every education component work together to practice students' thinking ability. It means that familiarizing students with HOTS activities is essential to help them solve new problems, adjust to new situations, and make decisions about specific issues (Indiani & Retnawati, 2017).

In practical reviews, with innovative learning, for example, problem-based learning, students become more challenged to explore various possible ideas that can be used to solve problems (Ezi Apino & Retnawati, 2016; Jailani & Retnawati, 2016)which used pretest-posttest experimental non-equivalent control group. Experimental class was a class which was taught by using problem-based learning, while the control class was a class which was taught by using direct instruction. The population of this research was the seventh graders of several Junior High Schools in DI Yogyakarta which have implemented problem based learning. The samples of this research were 515 students of Junior High School students from 10 schools in four districts and one city in Yogyakarta. The schools from which the samples were taken were both public and private schools which were selected based on their achievement in the national examination. The schools were selected using stratified random sampling, while the classes were selected randomly. The quantitative data analysis was conducted by using both descriptive and inferential statistic. The results showed that: (1. Loewen (Loewen, 1995) suggested that giving contextual creative problems and placing students dominant in learning can produce students' awareness that not all issues have only one correct solution. It can trigger and train students' creativity in learning, and creativity is part of HOTS. Another factor that causes an increase in students' HOTS is that innovative learning tends to lead to meaningful learning activities. Students are actively involved in the discussion process to build knowledge and utilize various relevant sources to explore the desired knowledge. These findings are consistent with Bohan & Bohan (Bohan & Bohan, 2020) that the learning process involving students' active participation to solve various problems can present meaningful learning activities for students and enhance students' higher-order performance thinking skills.

The results are relevant to previous studies. The learning to improve or train HOTS students can be done with several activities, such as involving students in problem-solving activities, providing opportunities for students to build their knowledge and improve their abilities, the ability to analyze, evaluating, and creating (Apino & Retnawati, 2017), involves students undergoing group discussions and communicating the results of problem-solving through presentations (Djidu & Jailani, 2016). In other words, building a learning-oriented HOTS can be done by minimizing teachers' dominance and maximizing the role of students in the learning process. Learning like this corresponds to innovative learning. There are at least three strategies carried out by teachers in implementing innovative learning, first in planning activities, namely teachers preparing physically and mentally, preparing HOTS-based lesson plans, preparing media, and appropriate evaluations. Second, in core learning, the teacher conducts learning using innovative learning steps, such as problem-based learning, starting from presenting problems, such as how to save fuel, organizing learning, directing constructively how to save fuel, presenting the results of discussions, and concluding. Third, closing the lesson by making conclusions together and evaluating with HOTS-based questions covering aspects of attitudes, knowledge, and skills (Inayati, 2020) which is required learning model with high level-thingking or commonly known as HOTS (Higher Order Thinking Skills.

Besides n the context of increasing students' HOTS achievements, this innovative learning is also expected to minimize and even eliminate student difficulties in solving HOTS problems. It is important because conditions in the field have not fully implemented innovative learning. As a result, HOTS students' achievement is still low, marked by students' difficulties when faced with questions that measure HOTS. Research by Hadi, Retnawati, Munadi, Apino, & Wulandari (Hadi et al., 2018) mentioned that the most common problem for students in completing test questions that measure HOTS is mathematical process skills. This difficulty is demonstrated by errors in implementing formulas, mathematical calculations errors, and errors in algebraic operations and manipulation. This condition suggests that one alternative that can be applied is innovative learning that facilitates students to optimize their thinking skills, including HOTS students.

Conclusion

This meta-analysis study investigates the effect size of innovative learnings on achieving student HOTS. It was found that the innovative learning applied had an effect on the achievement of students' HOTS and there was no potential for publication bias regarding the conclusions drawn. So that the conclusions made based on the random effect model about the application of innovative learning affect the achievement of students' HOTS are valid. These results indicate that innovative learning can be used as learning carried out in the classroom because it is empirically able to facilitate the achievement of students' HOTS.

Limitation and Suggestion

This meta-analysis study also has limitations in combining research results related to innovative learning in students' achievement of HOTS based on the mean value. First, the data collection used is limited to data whose mean values are explicitly stated, even though there may still be many research results that have not been included which are considered relevant. Second, in determining the research results (study) used as data, they did not consider the characteristics of the students (sample) who were in the study. In future research, it is hoped that the studies used in this meta-analysis will consider more studies and consider the characteristics of students (samples) so that the meta-analysis results are more valid.

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