

The Effect of the Scientific Approach on Enhancing Elementary School Students' Learning Outcomes in Indonesia: A Meta-Analysis

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Abstract— The 2013 curriculum provides a conception that the scientific approach to learning includes observing, asking, reasoning, creating, communicating. The scientific approach is appropriate for science because it is a student-centered learning approach and the learning process conforms to scientific criteria. This study aimed to investigate the effect size of the scientific approach on improving the science learning outcomes of Indonesian elementary school students. This study uses meta-analysis data in the form of descriptive exploratory quantitative. This study uses data collected in the form of journal articles, theses, and publication texts that are sought from the “Indonesia Onesearch” portal. Data analysis was performed by calculating the effect size of the same findings for similar problems. Results of tracing scientific publications obtained 20 documents published between 2013-2018 based on certain criteria. The results of this study indicated that the average effect size of the scientific approach to improving science learning outcomes of elementary school students is 1.1, including in the high category. The result of the effect size value shows that the scientific approach contributes 84%-88% to the improvement of science learning outcomes of Indonesian elementary school students. The implication of this research lies in the development of a scientific approach to various changes in the elementary school learning process following the mandate of the 2013 curriculum.

Keywords— *Meta-Analysis, Scientific Approach, Science Learning Outcomes*

I. INTRODUCTION

The problems that are quite concerning from education in Indonesia especially in the field of Natural Sciences can be seen from the results of the TIMSS (Trends in Student Achievement in Mathematics and Science) survey. TIMSS is a study that is carried out every four years, namely in 1995, 1999, 2003, 2007, 2011, and so on [1], [2]. Indonesia is at the bottom of the list compared to several countries in Asia. The average science achievement score of Indonesian students in TIMSS 1999, 2003, 2007, 2011, and 2015 was 435, 420, 427, 406, and 397 respectively [3]. These scores provide

information that Indonesian students were ranked 32 out of 38 countries in 1999, ranked 35 out of 46 countries in 2003, ranking 35 out of 49 countries in 2007, ranking 39 out of 42 countries in 2011, and ranking 45 out of 48 countries in 2015 [4], [5]. Meanwhile, in the field of education research by the OECD in the 2009 International Student Assessment (PISA) study program, it showed that Indonesia was able to count, read and science education was ranked 60 out of 65 countries, but in 2012 it fell to rank 64 [6], [7]. The results of the two surveys show that Indonesia has experienced a significant decrease in Human Resources, especially in the field of science education.

Related to the dimensions of science as a product and process, learning should be taught to students how this knowledge is found by students [8]. There are still many teachers who do not have adequate knowledge and skills in selecting and implementing various learning methods and approaches that can increase curiosity, activeness, interest, and motivation [9], [10]. The teacher must choose a learning approach that is by the characteristics of the student so that it can affect students' science learning outcomes. A suitable approach used to increase student activity in the learning process is a student-oriented approach. One approach that can develop the teacher's role as a facilitator and guide for developing students' potential is to use a scientific approach.

The 2013 curriculum provides a conception that the scientific approach in learning includes learning: observing, asking, reasoning, trying/creating, presenting/communicating [11], [12]. This scientific approach is appropriate for use in science subjects because it is a student-centered learning approach and at the same time the learning process meets scientific criteria. Stating that the scientific approach, calls the scientific learning process model is learning based on a scientific approach oriented toward fostering students' ability to solve problems through a series of inquiry activities that demand critical thinking skills, creative thinking, and communication to improve abilities and student knowledge

[13], [14]. The characteristics of the scientific approach according are objective, factual, systematic, meticulous, and precise method, logical, actual, disinterested (impartial learning), unsupported opinion (does not foster an opinion or opinion that is not accompanied by real evidence), and verification. Besides having characteristics, there are also learning objectives with a scientific approach [15], [16]. Some of the learning objectives with a scientific approach are (1) increasing intellectual ability, especially thinking skills in high-level students, (2) forming students' abilities to solve the problem systematically, (3) creating learning conditions where students feel that learning is a form of learning needs, (4) obtained high learning outcomes, (5) train students in communicating ideas especially in writing scientific articles, (6) develop student character [17], [18].

A scientific approach is a basic approach in the 2013 curriculum. Learning activities in the 2013 curriculum for all levels are carried out using a scientific approach. The scientific approach is believed to be a golden bridge for the development of students' attitudes, skills, and knowledge. The implementation of the 2013 curriculum in addition to using a scientific approach, another characteristic of 2013 curriculum is that there is a change in the content or teaching material components. Subjects are presented thematically or integrated. One of the subject's contents in the curriculum structure in elementary is Natural Sciences. Science is a group of knowledge that has special characteristics that study natural phenomena that are factual in the form of reality or events, and the cause and effect relationship [19], [20]. Research on the effect of applying the scientific approach to student science learning outcomes in elementary schools has been widely conducted and it turns out the results reveal that the scientific approach can improve student learning outcomes in science elementary schools.

Based on observations and tracing of scientific publications conducted through the "Indonesia Onesearch" portal, 53 studies have been found on these published between 2013-2018. All of these studies are still very poor in readability, even though the results of these studies can be used by teachers, students, parents, students, researchers, and various interested parties to obtain various information. The information obtained includes improving the quality of learning outcomes, the quality of learners, textbooks, teaching materials, and can determine the steps and actions needed in further research or just as a means of adding insight and knowledge.

Most researchers find it difficult to follow the rapid development of research results published through online journals or repositories. The researchers highly depend on the summary of the available research results. There are two methods developed to summarize research, namely the meta-analysis method and the meta-ethnographic method. Research on the effect of the scientific approach on improving science

learning outcomes of elementary school students has been widely carried out, so it is necessary to conduct a meta-analysis to get a unified understanding or general conclusions from a similar study. The urgency of this research is to get the same understanding or general conclusions from similar research and can be used as a result of preliminary research in further research on scientific approaches in science learning. So this meta-analysis was carried out to investigate the effect size of the scientific approach on improving the science learning outcomes of Indonesian elementary school students. The implication of this research is to develop a scientific approach for various changes in the elementary school learning process following the requirements of the 2013 curriculum.

II. METHODS

This type of research is a meta-analysis. A meta-analysis method is a form of a quantitative summary that examines the results of research statistically. Meanwhile, the meta-ethnographic method is a form of qualitative summary. The meta-analysis method is considered more objective (focusing on available data) so that the results obtained are more accurate and credible [21]. The meta-analysis states the results of the study using effect size (ES). Effect Size (ES) indicates the extent to which a variable affects other variables in a study or shows how effectively a variable influence other variable. The basic aim of the meta-analysis is to provide methodological similarities with the literature review needed from an experimental study [22], [23].

Meta-analysis is conducted by summarizing research data, reviewing and analysing research data from several existing research results. This study uses data collected in the form of journal articles, theses, and publication texts that are sought from the Indonesia One Search (IOS) portal. Data collected from the "Indonesia One Search portal (IOS)" is limited between 2013-2018 and with the keywords "*Pengaruh Pendekatan Saintifik*" which means effects of scientific approaches and "*Hasil Belajar IPA di Sekolah Dasar*" which means science learning outcome in elementary school obtained a small population of 53 scientific publications in the form of journal articles and scientific publication others. Subsequently selected so that a sample of 20 scientific publications are selected that meet the criteria, namely: (1) the results can state the effect size of the approach used has an impact on students' science learning outcomes in elementary schools; (2) several scientific publications that have been found were not selected because they did not mention or describe in full the quantitative descriptive manner so that the vaccine effect value could not be calculated.

The data analysis techniques for calculating effect size uses the statistical formula presented by [24], which can be seen in Table I.

TABLE I. EFFECT SIZE FORMULAS

Given Statistical Data	Formulas
Average and standard deviation in one group	$ES = \frac{\bar{x}_{post} - \bar{x}_{pre}}{SD_{pre}}$
Average and standard deviation in each group (two groups only posttest)	$ES = \frac{\bar{x}_{experiment} - \bar{x}_{control}}{SD_{control}}$

Given Statistical Data	Formulas
The mean and standard deviation of each group (two groups were pre-posttest)	$ES = \frac{(\bar{x}_{post} - \bar{x}_{pre})_{experiment} - (\bar{x}_{post} - \bar{x}_{pre})_{control}}{\left(\frac{SD_{pre\ control} + SD_{pre\ experiment} + SD_{post\ control}}{3} \right)}$
t value	$ES = t \sqrt{\frac{1}{n_{experiment}} + \frac{1}{n_{control}}}$

The results of the effect size values can then be interpreted into the high, medium, and low categories using the categories presented by [25], these categories can be seen in Table II.

The results of the effect size obtained can be interpreted to determine how much influence the independent variable has on the dependent variable with the conditions shown in Table III [26].

TABLE II. CATEGORY EFFECT SIZE INTERPRETATION

Effect Size (ES)	Standard Cohen's Category
$0 \leq ES \leq 0,2$	Low
$0,2 \leq ES \leq 0,8$	Medium
$ES \geq 0,8$	High

TABLE III. INTERPRETATION OF EFFECT SIZE (ES) EFFECT OF INDEPENDENT ON DEPENDENT VARIABLES

ES	0,0	0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9	1,0	1,2	1,4	1,6	1,8	2,0	2,5	3,0
Effect (%)	50	54	58	62	66	69	73	76	79	82	84	88	92	95	96	98	99	99,9

III. RESULT AND DISCUSSION

In this study, the number of scientific publications in the form of articles and publication manuscripts following the

research objective was 20 scientific publications. The details and calculation of the effect size are carried out to determine the effect of the scientific approach to the improvement of science learning outcomes of students in elementary schools shown in Table IV.

TABLE IV. DETAILS AND CATEGORY EFFECT SIZE OF SCIENTIFIC PUBLICATIONS

Author/Year	Research Design	$\bar{x}_{experiment}$	$\bar{x}_{control}$	$SD_{control}$	ES	Category
Ni Made Eny dan Rismayanti, Ni Wayan Arini, dan Made Sumantri/2015	Posttest-Only Control Group Design	18,67	14,08	2,92	1,6	High
Rahmani/2016	One Group Pretest-Posttest Design	$\bar{x}_{post} = 83,07$	$\bar{x}_{pre} = 73,77$	$SD_{pre} = 5,72$	1,6	High
Derry Hargiyantoro/2014	Pretest-Posttest Control Group Design	$\bar{x}_{pre} = 41,13$ $\bar{x}_{post} = 47,72$	$\bar{x}_{pre} = 52,14$ $\bar{x}_{post} = 48,85$	$SD_{pre} = 10,89$ $SD_{post} = 11,11$ $SD_{pre(Exp)} = 13,71$	0,8	Medium
Lastian Dwi Hastuti dan Veator Renyaan/2017	Posttest-Only Control Group Design	18,063	14,563	5,61	0,6	Medium
Ni Wayan Putri Yuliana, I Wayan Rinda Suardika, dan I Ketut Ardana/2015	Non-equivalent Control Group Design	77,16	70,45	8,23	0,8	Medium
I Made Adi Arnawa, I Wayan Rinda Suardika, dan I Ketut Ardana/2015	Randomized Control-Group Pretest-Posttest Design	75,80	66,50	11,96	0,8	Medium
Komang Ayu Tri Astiti, I Wayan Rinda Suardika, dan I Ketut Ardana/2015	Randomized Control-Group Pretest-Posttest Design	82,08	71,56	9,15	1,1	High
I Ketut Restana Arta, Anak Agung Gede Agung, dan I Wayan Widiana/2015	Non-equivalent Control Group Design	21,3	14,7	3,35	2,0	High

Ni Luh Putu Tiyani, I Wayan Rinda Suardika, dan I Ketut Ardana/2015	Non-equivalent Control Group Design	74,05	70,38	14,76	0,2	Medium
Ni Luh Eka Sawitri, I Wayan Rinda Suardika, dan I Ketut Ardana/2015	Non-equivalent Control Group Design	72,30	58,32	16,75	0,8	Medium
Putu Desi Ratnasari, Anak Agung Gede Agung, dan I Wayan Widiana/2015	The Posttest-Only Control Group	24,9	22,8	4,2	0,5	Medium
Praba Wahyu Hidayat/2015	One Group Pretest-Posttest Design	tvalue=4,75 ne=32 nc=32			1,2	High
Elgita Herviani Munggaran/2018	Pretest-Posttest Control Group Design	tvalue=3,12 ne=27 nc=24			0,9	High
Ni Ketut Tiwik Nuryani, I Wayan Wiarta, dan Made Suara/2016	Non-equivalent Control Group Design	tvalue=4,18 ne=39 nc=38			1,0	High
Siti Syarifah, Arifin Ahmad, dan Andi Cudai Nur/2016	Non Ekuivalen Pretest-Posttest Design	$\bar{x}_{pre} = 53,69$ $\bar{x}_{post} = 71,74$	$\bar{x}_{pre} = 53,48$ $\bar{x}_{post} = 60$	$SD_{pre} = 6,48$ $SD_{post} = 8,65$ $SD_{pre(Exp)} = 10,3$	1,4	High
Ni Kadek Tariani, Ni Ketut Suarni, dan I Gede Astawan/2015	One Group Pretest-Posttest Design	$\bar{x}_{post} = 72,11$	$\bar{x}_{pre} = 50,22$	$SD_{pre} = 15,49$	1,4	High
Komang Trisna Mahartini, Ni Ketut Suarni, dan I Gede Astawan/2015	One Group Pretest Posttest Design	$\bar{x}_{post} = 72,98$	$\bar{x}_{pre} = 46,55$	$SD_{pre} = 11,09$	2,4	High
Siti Maskanah/2015	The Posttest Only Control Group Design	64,25	58,45	12,16	0,5	Medium
Muhammad Asrofi/2016	One Group Pretest Posttest Design	tvalue=5,59 ne=28 nc=28			1,5	High
Raihan Fannesa/2018	Non-equivalent Pretest-Posttest Control Group	79	69,142	14,005	0,7	Medium
Σ Effect Size (ES)					21,8	
Average Effect Size (ES)					1,1	
Maximum Effect Size (ES)					2,4	
Minimum Effect Size (ES)					0,2	
Standard Deviation (SD)					0,537	

From table IV it can be seen that the results of the calculation of effect size prices obtained the highest effect size is 2.4 categorized in the high category so that shows that the scientific approach influences 98% - 99% on the science learning achievement of elementary schools' students and the lowest effect size is 0, 2 is categorized as low so it shows that the scientific approach has an effect of only 58% on the learning outcomes of science students in elementary schools. Meanwhile, the average effect size of 1.1 (SD = 0.537) is categorized as high. These results show that the effect of the scientific approach can improve student science learning outcomes in elementary schools by 84% - 88% (can be seen in Table III). The results of the distribution of effect sizes based on their categories can be illustrated in the pie chart in Figure 1.

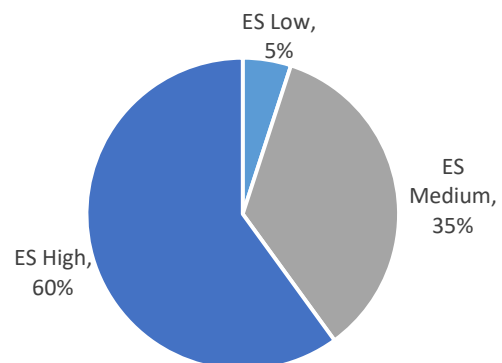


Fig. 1. Distribution of Effect Size (ES) Categories

Based on Figure 1 shows that the effect size of scientific publications about the effect of the scientific approach to the

improvement of science learning outcomes of students in elementary schools which are included in the low category is only 5%, including the moderate category 35%, and those included in the high category 60%.

This illustrates in Figure 1. shows that the scientific approach has a high influence on student learning outcomes in elementary school. This can occur because the Scientific approach is learning that encourages children to carry out the following scientific skills: observing; ask; gathering information; associate; and communicating [19], [27]. In the scientific approach to the learning process, the teacher provides direct experience, and students are allowed to be active in learning activities where students can use their minds to build understanding. All activities in a scientific approach stimulate students to be active, both physically and mentally. This makes students not only learning objects but learning subjects. The application of the Scientific Approach in science learning makes students enthusiastic in learning because the method can provide opportunities for students to better understand what the goals of problems exist in learning and provide more understanding to students to solve the problems presented through gradual guidance. This was also stated by Vygotsky [28], [29] that the purpose of the scientific approach is to improve intellectual ability, especially thinking skill in high-level students, to shape the ability of students to solve a problem systematically, creating learning conditions where students feel that learning is a necessity, obtain high learning outcomes, to train students in communicating ideas, especially in writing scientific articles and to develop student character. Science education based on science process skills enhances students' scientific problem-solving skills, supports curiosity because it provides direct learning, improves the quality of education as it develops questioning and reasoning skills of the students [30], [31]. Other constructivist learning methods, such as problem-based learning, inquiry-based learning, process-oriented guided-inquiry learning, project-based learning, research-based learning, or other methods that have the potency to give a big impact [32], [33].

IV. CONCLUSION

Based on the results of the meta-analysis that has been carried out, it can be concluded that (1) the average effect size of the effect of the scientific approach to the improvement of science learning outcomes of elementary schools students by 1.1 (SD = 0.537) is included in the high effect size categories. The results of the effect size values show that the scientific approach contributes 84%-88% in improving student science learning outcomes in elementary schools; (2) the highest effect size is 2.4 categorized in the high ES category so that it shows that the scientific approach has an effect of 98%-99% on the science learning achievement of elementary school students. Suggestions for researchers and practitioners to use the results of this study to develop a scientific approach to improving student learning outcomes, especially in science learning. Moreover, it can also be used as a result of preliminary research in further research on scientific approaches in science learning.

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