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Meta-Analysis: The Effect of Learning Models on Students' Scientific Literacy

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ABSTRACT (10 PT)

In the 21st century, where technology and science are developing rapidly, scientific literacy is very important. Technology and scientific literacy in particular can help improve the quality of a country's education. By collecting 20 research results, this meta-analysis research aims to summarize research findings regarding the influence of learning models on students' scientific literacy abilities. This research aims to find out: the average effect size (ES) of which type of learning model has the largest effect size at the level of education, and which learning model has the most influence on students' scientific literacy. The results of the research show that the average ES is 1.21, which shows that the use of learning models has a significant impact on students' scientific literacy. The type of learning model most often used to increase students' scientific literacy is the Problem-Based Learning model with an average ES of 1.28. The Problem-Based Learning model is more influential at the high school education level with an average ES of 1.58 and on science material of 1.30 with an effect size in the high category.

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INTRODUCTION

In the 21st century science and technology (IPTEK) is developing rapidly. With today's technology, everything can be managed easily. Humans must understand the development of science and technology and be able to use it wisely to keep up. To become quality human resources, people, especially students, must be able to compete and adapt as times progress. One way to improve human resources is through improving the quality of education (Pertiwi & Rusyda Firdausi, 2019). Education is very important for human life, especially in the 21st century, because students must be reliable and have the qualities needed to face the challenges of the 21st century. Education quality can be improved by increasing students' scientific literacy abilities (Novita et al., 2021).

Scientific literacy is a person's ability to use brand knowledge, discover new problems, explain scientific phenomena, and make conclusions based on relevant evidence (Wulandari

& Wulandari, 2016). The 2018 PISA assessment data shows that Indonesian students' scientific literacy is ranked 70th out of 79 countries, with a score of 396, indicating that Indonesian students' scientific literacy is still very low at the international level (OECD, 2018). This score has decreased compared to 2015, when Indonesia was ranked 62nd out of 70 countries with a score of 403 (OECD, 2015).

The education system implemented, the model chosen, approaches, strategies, learning methods, student learning styles, and the facilities used in learning are several factors that are thought to be the cause of the low scientific literacy of students in Indonesia (Rusilowati et al., 2016). However, considering these factors, this problem cannot be solved simply by applying learning models, strategies, or methods (Triandini et al., 2019).

Based on the result of previous research to help intervene in the effectiveness of various learning models that can be used to improve students' scientific literacy skills. So meta-analysis research on the influence of the use of learning models on students' scientific literacy abilities needs to be carried out to help educators and researchers identify the most successful learning models for increasing students' scientific literacy according to the level of education they are undertaking.

METHODS

This study uses a literature study that analyzes data from similar studies, or it can also be called a meta-analysis. Meta-analysis is quantitative because the calculations use numbers and statistics which aim to organize information from many data sources. The stages in this research start from determining the title of the research, collecting data through data coding to make it easier to analyze the data, analyzing the effect size from the results of research data collection, and concluding the results of data analysis by predetermined criteria.

The data used is secondary data originating from 20 articles selected based on the model used and the various approaches used by the articles, (1) the articles used are articles accredited in National Journals and International Journals, (2) articles that examine the influence of using learning models on students' scientific literacy, (3) articles published in the last 7 years. The variables in this research are the learning models used, including the guided inquiry model, free inquiry, problem-based learning, project-based learning, and discovery learning with the dependent variable being students' scientific literacy abilities.

In a meta-analysis study, the effect size will show the magnitude of the effect caused by the learning model on students' scientific literacy. Effect size (ES) can be obtained by calculating the effect size using the Becker and Park formula presented in Table 1. And the effect size can be categorized according to Cohen's level which can be seen in Table 2.

To calculate the effect size value of the 20 sample articles that have been obtained, the effect size calculation equation can be used as listed in Table 1. Six formulas can be used to measure the effect size, the use of which can be adjusted according to the data listed in the sample articles.

Table 1. The Equation for Determining the Effect Size

Statistics	Formula	Formulas
Average in one group	$ES = \frac{\bar{X}_{post} - \bar{X}_{pre}}{SD_{pre}}$	Fr-1
Average in each group (two groups posttest only)	$ES = \frac{\bar{X}_E - \bar{X}_C}{SD_C}$	Fr-2

Average in each group (two groups pre-post test)	$ES = \frac{\left(\bar{X}_{post} - \bar{X}_{pre}\right)_E - \left(\bar{X}_{post} - \bar{X}_{pre}\right)_C}{\frac{SD_{preC} + SD_{preE} + SD_{postC}}{3}}$	Fr-3
Chi-square	$ES = \frac{2r}{\sqrt{1-r^2}}; r = \sqrt{\frac{x^2}{n}}$	Fr-4
T count	$ES = t\sqrt{\frac{1}{n_E} + \frac{1}{n_C}}$	Fr-5
P value	CMA (Comprehensive Meta-Analysis Software)	Fr-6

(Fauzi et al., 2022)

Meanwhile, in determining the effect size category, categorization is used, namely $0 \leq ES \leq 0{,}2$ for low category, $0.2 \leq ES \leq 0.8$ for the medium category, and $ES \geq 0.8$ for the hight category (Marlina et al., 2021).

RESULTS AND DISCUSSION

Results

After collecting 20 national and international articles according to the criteria for articles to be analyzed and researched as variables, the resulting data on the magnitude of the effect was obtained as in Table 2.

Table 2. Article Effect Size Categories

Journal Code	Writer	Formulas	ICE	Category
J1	Fa'idah et al., 2019	Fr-4	2.03	High
J2	(Aiman et al., 2019)	Fr-2	0.80	Moderate
J3	(Fitriani et al., 2017)	Fr-3	2.21	High
J4	(Eviani et al., 2020)	Fr-3	1.94	High
J5	(Haerani et al., 2020)	Fr-3	1.16	High
J6	(Afriana et al., 2016)	Fr-4	2.00	High
J7	(Yaumi et al., 2017)	Fr-4	2.00	High
J8	(Mutasam & Susilo, 2019)	Fr-1	1.03	High
J9	(Shellawati & Sunarti, 2018)	Fr-3	0.47	Moderate
J10	(Banila et al., 2021)	Fr-1	0.9	High
J11	(Zulfa et al., 2022)	Fr-3	1.06	High
J12	(Khotimah et al., 2020)	Fr-3	0.76	Moderate
J13	(Erdani et al., 2020)	Fr-3	0.66	Moderate
J14	(Lendeon & Poluakan, 2022)	Fr-3	0.96	High
J15	(Adiwiguna et al., 2019)	Fr-3	0.12	Low

Journal Code	Writer	Formulas	ICE	Category
J16	(Jofi Kuswanto et al., 2021)	Fr-3	0.99	High
J17	(Giriyanti et al., 2017)	Fr-3	0.56	Moderate
J18	(Aiman, Amelia Ramadhaniyah Ahmad, et al., 2020)	Fr-2	1.80	High
J19	(Ratini et al., 2018)	Fr-2	2.49	High
J20	(Aiman, Hasyda, et al., 2020)	Fr-2	0.26	Moderate

The article code, effect size, and effect size criteria for the effect of the learning model on students' scientific literacy are presented in Table 3. Table 3 shows that the effect of using the learning model on students' scientific literacy. There are 13 articles in the high category, 6 articles in the medium category, and 1 article in the low category. Overall, the articles analyzed were dominated by effect sizes in the high category. This means that the use of learning models in the teaching and learning process greatly affects students' scientific literacy skills.

The next analysis was carried out on the 20 articles found, namely about the effect of the use of learning models on students' scientific literacy, again grouped based on their level of education and the type of learning model used. This is done with the aim of making the resulting analysis more in-depth and specific. In addition, the purpose of the analysis based on educational level and learning model is to help researchers compare the size of the effect sizes found in each article with other similar studies. Overview of the results of the effect size analysis of the influence of the use of learning models on students' scientific literacy abilities, namely in terms of educational level. The level of education reviewed is based on the 20 articles that have been found, namely at the level of elementary school, junior high school, and senior high school, which then determines the average effect size of the child at each level.

Table 3. Effect Size Calculation Data Based on Education Level

Educational level	Mean Effect Size	Category
Senior High School	1.21	High
Junior High School	1.25	High
Elementary school	1.15	High

The educational level, average effect size, and effect size criteria shown in Table 3 were obtained from the analysis of 8 articles at the high school level, 6 articles for the middle school level, and 6 articles for the elementary school level. However, at the tertiary level, it was not found in this research article. It is known that the effect size is in the high category at the SMA, SMP, and SD levels. This shows that, compared to not using a learning model, using a learning model in the teaching and learning process has a better impact on students' scientific literacy. The average effect size obtained at the three levels of education has no significant differences, this means that at the high school, middle school, and elementary school levels, the use of learning models can encourage students' scientific literacy skills.

In addition, the influence of the use of learning models in the learning process is studied by considering the type of learning model used. This was done to allow readers to compare the differences in the effect size of each type of existing learning model because each learning model has a different influence on students' scientific literacy. Data from the large effect size

calculation using the type of learning model on students' scientific literacy is in Table 4.

Table 4. Effect Size Calculation Data Based on the Type of Learning Model

Model	Mean effect size	Category
Guided Inquiry	0.88	High
Free Inquiry	1.09	High
Problem-Based Learning	1.28	High
Project Based Learning	1.38	High
Discovery Learning	2.00	Very High

Calculation of the effect size of the influence of the type of learning model used on students' scientific literacy is shown in Table 4. Based on Table 4 types of learning models have been used to help improve students' scientific literacy based on the articles analyzed, 5 articles use the inquiry learning model guided to encourage students' scientific literacy, 2 articles use free inquiry, 10 articles use the problem-based learning model, 2 articles use the project-based learning model, and 1 article uses the discovery learning model. From this explanation, it can be understood that the use of the problem-based learning model is more widely used by educators to encourage students' scientific literacy, with an effect size of 1.28 in the high category.

Discussion

Based on previous research, students' scientific literacy abilities can be improved through various efforts. Some of these efforts include the use of teaching materials based on scientific literacy, the application of appropriate learning models and approaches to increase students' scientific literacy, and the use of evaluation tools, namely assessment instruments that help teachers assess their students' scientific literacy abilities. Applying models and approaches during the learning process can improve students' scientific literacy abilities. Apart from that, using this model and approach can cause students to have a positive response to the learning process. In addition, the use of this model and approach leads to positive evaluations for students. This statement is in line with previous research where several researchers used learning models and approaches such as science and technology-based project models (Afriana et al., 2016; Khotimah et al., 2020).

In addition, problem-based learning and student-centered learning models can be used to improve students' scientific literacy skills. The results of measuring the effect size of several existing learning models, the learning model that is widely used to encourage students' scientific literacy is the problem-based learning model (Aiman et al., 2019; Firdausi Nuzula & Sudibyo, 2022; Fitriani et al., 2017). Apart from that, the inquiry model is considered effective as a learning model in the classroom because it requires students to think critically, creatively, and analytically to solve problems. The application of the inquiry model to increase students' scientific literacy has been widely carried out both at the elementary, middle and high school levels (Erdani et al., 2020; Fa'idah et al., 2019).

In the discovery learning model, students are trained to discover concepts directly through their experiences, which allows them to achieve several indicators of scientific literacy. The syntax contained in this model can be used to increase students' scientific literacy (Yaumi et al., 2017). From literature studies that have carried out the application of the discovery learning model in learning to increase students' scientific literacy, not much has been done, but several that have applied this model in learning have obtained results that have a high effect value for increasing students' scientific literacy.

CONCLUSION

The use of learning models in the teaching and learning process is effective in improving students' scientific literacy skills at the elementary, middle, and high school education levels. However, the use of learning models in the teaching and learning process has a higher influence value at the junior high school level. The use of a more effective learning model to improve students' scientific literacy skills is to use the discovery learning model with a very high effect size category, followed by the project-based learning model, problem-based learning, and finally, guided inquiry which has an effect size. the lowest among other learning models. This research implies that other researchers and educators can find more suitable models to use to improve students' scientific literacy skills so that implementation is more effective and efficient. Apart from that, it is hoped that there will be further research regarding the influence of the use of learning models on students' scientific literacy which will look at it in more depth and take into account variables that have not been covered by researchers.

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