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The Effectiveness of AI Based Blended Learning on Student Scientific Literacy: Meta-analysis

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Abstract
This study aims to analyze the effectiveness of blended learning based on artificial intelligence (AI) on students' science literacy. This type of research is called meta-analysis research. The data sources in the study came from 14 national and international journals published from 2018 to 2023. Data sources were searched through Google Scholar, ScienceDirect, Wiley, Eric, and ProQuest. Data source selection was carried out using the PRISMA method. Data sources have a relationship with the effectiveness of AI-based blended learning on students' science literacy. The data collection technique was direct observation through an online database. Data analysis used quantitative analysis with the help of the OpenMEE application. The results of this study showed that the AI-based blended learning model had a significant effect on students' science literacy. The effect size value is 0.93 with high criteria. This finding helps potential students improve their science literacy.

Keywords: Blended Learning, Education, Artifician Intelligence, Science Literacy, Meta-analysis

INTRODUCTION

Science literacy is a student's knowledge in identifying a problem to gain new knowledge related to science (Adiwiguna et al., 2019; Mariyam Shareefa, 2020; Ichsan et al., 2022; Legvart et al., 2021). Science literacy is very important for students to solve problems in learning (Gao et al., 2022; Norton-Meier et al., 2013). Students who have science literacy skills will be able to apply the knowledge they have in life. (Aiman & Ahmad, 2020;Alatas & Fauziah, 2020; Suharyat et al., 2023; Cesljarev & Akerson, 2022). Science literacy is key in education since students are 15 years old in implementing science learning. (Afriana et al., 2016; Sutiani et al., 2021; Irby et al., 2021). In addition, students who have science literacy are able to encourage critical thinking skills, creative, innovative, and scientifically empowered (Anggreni et al., 2020; Rahman et al., 2023; Suhaimi et al., 2022; Zulkifli et al., 2022).

Based on the results of PISA-OECD, the level of science literacy of Indonesian students is still relatively low (Supriyadi et al., 2023; Elfira & Santosa, 2023; Ichsan et al., 2023; Razak et al., 2021). According to the results of PISA in 2018, Indonesian students' literacy has a score of 396, ranked 73 out of 79 participating countries (Aiman & Ahmad, 2020). According to (Lendeon & Poluakan, 2022) students have not been able to relate the science concepts learned to the real environment. In addition, students' interest in learning science is still low (Jufrida et al., 2019; Dewi et al., 2021), causing students to be less interested in learning (Razak et al., 2022). Furthermore, the low level of science literacy of Indonesian students is influenced by the learning model, media, resources and teaching materials used by teachers in schools (Aulia et al., 2021). One solution is to improve the learning model used by teachers.

Blended Learning is a learning model that can improve students' science literacy in learning (Rahmi et al., 2022; Suparno et al., 2022). Blended learning is a learning model that can be done online and offline. (Damanik, 2020; Choi & Park, 2022; Chuane et al., 2022). Selanjutnya, menurut (Bozkurt, 2022) Blended learning is a learning model that can be done face to face and through the internet through a particular platform. Blended learning model can improve student learning outcomes (Santosa et al., 2021), So that

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students are more active in learning. Blended learning model can improve students' problem solving ability and concept understanding (Sudiarta & Sadra, 2016). (Nugraha et al., 2019). The blended learning model based on Artificial intelligence (AI) is a new model that can improve student literacy in Indonesia.

Artificial Intelligence (AI) helps make student learning more effective and engaging (Viktorivna et al., 2022). Artificial Intelligence helps students more easily explain the subject matter (Pakpahan, 2021) Artificial Intelligence helps students in overcoming students' science learning problems so as to make students more creative and innovative. Artificial Intelligence encourages students to improve their 21st century skills (Westman et al., 2021; Cope et al., 2021).

Previous research by (Sari & Wibowo, 2021) The blended learning model has a positive effect on student achievement and motivation. Research by (Rahmi et al., 2022) blended learning model influences students' and teachers' digital literacy (Soutthaboualy et al., 2021) blended learning model is effectively applied in the learning process in supporting students' cognitive enhancement. Research by (Bayyat et al., 2021) blended learning model can improve students' digital literacy (Prince et al., 2020) stated that the blended learning model influences students' thinking skills in learning. Research by (Seage & Türegün, 2020). The blended learning model has a positive influence on students' science, technology and mathematics levels. Based on the above problems, this study aims to analyze the effectiveness of blended learning based on Artificial Intelligence (AI) on students' science literacy.

METHODS

This research is a type of meta-analysis research. Meta-analysis is a type of research that analyzes studies that can be statistically analyzed (Supriyadi et al., 2023; Apra et al., 2021; Santosa & Sepriyani, et al., 2021; Suharyat et al., 2022; Setiawan et al., 2022; Ichsan et al, 2022). The study was used to determine the effect of AI-based blended learning model on students' science literacy. Meta-analysis research provides a general evaluation through quantitative data analysis (Martin et al., 2022; Agussuryani et al., 2022). The steps to conduct a meta-analysis are 1) determining the inclusion criteria to be analyzed; 2) Determine the procedure for collecting empirical data and coding the variables to be studied and; 3) perform statistical techniques to analyze the data.

Eligibility Criteria

All articles used as data sources in this study in the search process have been examined and assessed for meta-analysis using eligibility criteria, namely 1) national and international journals published from 2018-2023; 2) published articles come from journals and proceedings indexed by Scopus, SINTA, DOAJ and Web of Science (WOS); 3) research journals have experimental classes that use blended learning models and others use control classes and 4) all data studied attach data that can perform effect size transformations.

From the results of searching data sources, 14 national and international journals were obtained that met the above standards with a publication range of 2018-2023.

Data Collection

The empirical data in this research comes from journals or studies on the effect of blended learning model based on Artificial Intelligence (AI) on students' science literacy skills. The data used in this study came from the identification of each study from the google scholar database, ScienceDirect, Eric, Sage and Taylor of Francis. The keywords used in this study are the impact of blended learning model, blended learning, AI-based learning, students' science literacy and the effect of blended learning on students' science literacy.

Statistical Analysis

For data analysis in this meta-analysis research is the effect size (Li et al., 2022). The effect size in this study is an index that describes the effect of blended learning model based on Artificial Intelligence (AI) on students' science literacy skills. The method to calculate the effect size value follows Borenstein in (Funa & Prudente, 2021) The data were analyzed using the following methods: 1) calculating the effect size of each study; 2) conducting a heterogeneity test; 3) determining publication bias; 4) calculating the p-value to test the research hypothesis. In this study, data analysis used OpenMEE. The effect size criteria can be seen (Table.1).

Table 1. Effect Size Value Criteria

Effect Size	Criteria
ES ≤ 1.5	Ignored
1.5 ≤ ES ≤ 0.40	Small
0.40 ≤ ES ≤ 0.75	Moderate
0.75 ≤ ES ≤ 1.10	Hight
1.10 ≤ ES ≤ 1.45	Veri Hight
1.45 ≥ ES	High influence

Sumber : (Sofianora et al., 2023; Alqahtani, 2019;Suharyat et al., 2022;Karim et al., 2022)

RESULTS AND DISCUSSION

From the analysis, there are 14 national and international journals related to the effect of blended learning model based on Artificial Intelligence (AI) on students' science literacy, the effect size and standard error of each study can be seen (Table.2).

Table 2. Effect Size and Standard Error of Each Study

No	Author	Year	Effect size	Standard Error	Criteria
1	Kade *et al*	2019	0.92	0.61	Hight
2	Aritonang & Safitri,	2021	0.63	0.45	Moderate
3	Zulfa *et al.,*	2022	1.10	0.31	Very Hight
4	Pratama & Zilhakim,	2022	0.98	0.29	Hight
5	Masitoh,	2018	0.55	0.20	Moderate
6	Nisrina *et al.,*	2020	0.60	0.27	Moderate
7	Rohmawati *et al.,*	2021	2.72	0.67	High influence
8	Rahmi *et al.,*	2022	0.52	0.18	Moderate
9	Chuane *et al.,*	2022	1.50	0.35	Very hight
10	Katasila & Poonpon,	2022	0.70	0.21	Moderate
11	Li *et al.,*	2022	0.37	0.10	Small
12	Seage & Türegün,	2020	1.15	0.40	Very Hight
13	Wirdayani *et al.,*	2023	0.85	0.20	Hight
14	(Amelia et al., 2022)	2022	0.45	0.28	Moderate
Average effect size value			**0.93**		**Tinggi**

Based on Table 2. Explains the average effect size value of 0.93 with high criteria. It can be concluded that each study in the research has an influence. Furthermore, the model used in this meta-analysis research can be seen in Table 3.

Table 3. *Fix and Random effect*

	Q	DF	P
Omnibus test of Coefficients Mode	34.780		< 0.001
Test of Residual Heterogeneity	178.201	14	< 0.001

Based on Table 3. The Q value of 178.201 is greater than the 95% degree of freedom in the distribution table p-value <0.001. So, it can be concluded that the effect size distribution of the analyzed journals is heterogeneous. Therefore, the random effect model is more suitable for estimating the average effect size of the 14 studies analyzed.

Next, the issue of publication bias effect will be evaluated against the 14 analyzed studies. To assess the possibility of publication bias problem, we can be analyzed by calculating the Rosenthal fail-safe N (FSN) value. The results of the Rosenthal fail-safe N (FSN) test can be seen (Table 4.).

Table 4. Fail-Safe N

File Drawer Analysis			
	Fail-safe N	**Target Significance**	**Observed Significance**
Rosenthal	5043.000	0.50	<0.001

Based on Table 4. Shows the value of K = 14 then 5K + 10 = 5 (14) + 10 = 80. The value of the N-phase file obtained is 5043 with a sig value. 0.05 and p-value <0.001. Because the safe N file value > (5K + 10), it can be concluded that the meta-analysis study conducted does not have a publication bias problem and can be scientifically justified. Furthermore, Table 5. Shows the average effect size of the 14 studies analyzed.

Table. 5 Summary/Mean Effect Size

Coeficients						
	Effect size	Standar Error	z	P	95% Confidence Interval	
					Lower	Upper
Intercept	0.93	0.25	6.210	< 0.001	1.002	1.270

Based on Table 5. Shows that using a random effect model with a 95% confidence level has a lower limit of 1.002 and an upper limit of 1.270. With an average effect size of 0.93 and a standard error of 0.25 with high criteria. The Z test results show a value of 6,210 with a p-value <0.001. So, it can be concluded that the AI-based blended learning model has a significant effect on students' science literacy.

Discussion

The application of blended learning model based on Artificial Intelligence (AI) to students' science literacy has a positive influence on students' science literacy with an effect size value (ES = 0.93) with high criteria. This is in line with (Alajmi, 2021) stated that AI-based blended learning model affects science literacy and students' understanding in learning. (Mursid et al., 2022) blended learning model based on Artificial Intelligence (AI) can improve students' creative thinking ability and learning outcomes. The application of AI-based blended learning model is very necessary to be developed in student learning activities in Indonesia. AI-based blended learning model can be conducted face-to-face with students and indirectly through certain learning platforms (Shareefa, 2020; Uygur, 2022). Furthermore, the AI-based blended learning model becomes the teacher's solution in improving the students' literacy level in school (Bayyat et al., 2021; Soutthaboualy et al., 2021; Çiftçi, 2020).

Furthermore, the blended learning model based on Artificial Intelligence (AI) from various studies analyzed has a positive impact on students' knowledge development. Knowledge is information obtained by students from various sources (Ferry et al., 2020); Fradila et al., 2021; Santosa , et al., 2021). Students' knowledge in student literacy is very important to achieve learning goals. Thus, the Artificial Intelligence (AI)-based blended learning model provides benefits for students and teachers in promoting educational progress (Triawang & Kurniawan, 2021; Sumarmi et al., 2021). According to (Damanik, 2020) Blended learning model is the latest innovation in education.

The blended learning model provides many benefits in helping students' teaching and learning activities at school. This is in line with (Prastyo et al., 2020) The blended learning model is able to increase students' learning motivation. In addition, the blended learning model based on Artificial Intelligence (AI) improves students' digital literacy skills and 21st century thinking skills. AI-based blended learning model helps students to understand science literacy in all fields more easily.(ini et al., 2022; Tabieh & Hamzeh, 2022; Yang et al., 2022). AI-based blended learning improves students' critical thinking skills in learning (Harahap et al., 2019).

Furthermore, science literacy is an important thing in facing the industrial revolution 4.0. Students who have a high level of literacy will have younger adaptability.(Zulkifli et al., 2022; Santosa & Yulianti, 2020; Ichsan et al.,, 2023). Therefore, the blended learning model is a solution in helping teachers to develop more science literacy with other countries. The Covid pandemic era - 19 AI-based blended learning model is a very effective and efficient learning model in helping the learning process of students and teachers (Savitri et al., 2022;Ayasrah et al., 2022; Zulyusri el at., 2020). In developing the AI-based blended learning model, teachers must be able to apply science in everyday life. (Pinphet & Wasanasomsithi, 2022; Santosa & epriyani, et al., 2021). Models can be developed with various Artificial Intelligence (AI)-based technologies, saving teachers time and space to learn.

CONCLUSION

From this study, it can be concluded that the AI-based blended learning model has a significant effect on students' science literacy. The Effect Size value is 0.93 with high criteria. This finding helps potential students in improving their science literacy in learning. The AI-based blended learning model is very effective in helping students and teachers in learning activities. Furthermore, this model really needs to be developed in schools.

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