Formatif: Jurnal Ilmiah Pendidikan MIPA, September 2023, 13 (2), 199-216
http://dx.doi.org/10.30998/formatif.v13i2.15654
p-ISSN: 2088-351X e-ISSN: 2502-5457
Accredited (S2) by Ministry of Research and Technology of Indonesia No. 148/M/KPT/2020
Available online at https://journal.lppmunindra.ac.id/index.php/Formatif/index

Meta-Analysis of the Effect of STEM-Based Integrated Science E-books on Students' Scientific Literacy

Asrizal(*), Fleony Dea Amanda, Endang Aldilla, Jufiani Ulfa
Physics Education Postgraduate Study Program, Faculty of Mathematics And Natural Sciences, Padang State University

Abstract

There are three objectives of this research. First, to see how much influence is exerted by the use of STEM-based integrated Science e-books in terms of education level. Second, to see how much influence is exerted by the use of STEM-based integrated Science e-books in terms of the teaching model. Third, to see how much influence of the use of STEM-based integrated Science e-books has on students' scientific literacy. The type of research used was meta-analysis research which aimed to review several past studies using a quantitative approach. Based on the learning material carried out with the heterogeneity test, it was found that only three subjects had different populations, namely impulse and momentum material, vibration and waves, as well as environmental pollution, the results obtained are $Q < df$ so that the hypothesis test obtained from the results of $p < a$ in three eyes lesson H_0 is rejected. Based on the level of education, the results show that elementary school, junior high school and senior high school levels show a value of $Q > df$ so that the results of hypothesis testing at the elementary school, junior high school and high school levels show that the value of $p > a$, which indicate that testing the hypothesis H_0 is accepted. The results of testing the hypothesis at the higher education level show that the $p < a$, which shows that the hypothesis testing H0 is rejected. Based on scientific literacy testing of heterogeneity obtained $Q > df$ and using hypothesis testing the value of $p < a$ H_0 is rejected. The results of the analyzed data can be concluded that the integrated Science e-books on literacy have an effect on scientific literacy skills.

Keywords: Meta-Analysis, STEM, Integrated Science, E-books, Scientific Literacy

(*) Corresponding Author: asrizal@fmipa.unp.ac.id

How to Cite: Asrizal, et al. (2023). Meta-analysis of the effect of stem-based integrated science e-books on students' scientific literacy. *Formatif: Jurnal Ilmiah Pendidikan MIPA, 13* (2): 199-216. http://dx.doi.org/10.30998/formatif.v13i2.15654

INTRODUCTION

In the era of industrial revolution, technological developments increase rapidly, globalization is increasingly rampant. Technological developments that have occurred have led to change in people's lifestyle patterns globally, causing the need for the availability of skilled human resources. Technological developments have an impact on various aspects of human's life, including the field of education (Febrina, Leonard, & Astriani, 2020; Berliana et al., 2021). Education is the main basis for contributing to all sectors by providing what is needed both skills and knowledge. Skills in the 21st century are the main focus of education today, especially in integrated science education (Fuadi, 2020). For this reason, integrated Science learning needs to be properly implemented in Indonesia so that students have the skills needed in the 21st century (Mardianti et al., 2020).

The 21st century skills are the basic needs needed in integrated Science learning. In the appropriate application of integrated Science, students need a skill called scientific literacy. Scientific literacy is one of the main skills needed in the 21st century (Fuadi, 2020). Scientific literacy is a person's ability to apply his knowledge to identify questions,

to construct new knowledge, to provide scientific explanations, to draw conclusions based on scientific evidence, and the ability to develop a reflective mindset so that he is able to participate in overcoming issues and ideas related to Science (OECD, 2019).

According to the results of the Program for International Students Assessment (PISA) in the field of Science, literacy in Indonesia is still relatively weak and experiencing a decline. According to the International Students Assessment (PISA) in the field of scientific literacy, the results of the 2015 PISA assessment show that Indonesian students only got a score of 403 out of the total the OECD average score was 493 while the results of the 2018 PISA assessment, Indonesian students fell to 396 (Mukharomah et al., 2021). This shows that the ability of scientific understanding of students in Indonesia is still low. STEM creates problem-oriented learning in everyday life. Learning with the STEM approach students can be trained to apply the knowledge they have acquired at school to phenomena that occur in the real world and the STEM approach is action-oriented because it involves solving real problems that are located in the context of the students themselves (Ling et al., 2019)."

The STEM approach causes the creation of human resources who can solve environmental problems and can apply their knowledge into technology that can reduce damage and issues related to global issues so that the STEM approach model is effective because students use it in class (Jowsey et al., 2020). In its application, the STEM approach class can be implemented with the help of teaching materials. Teaching materials are divided into 2 types, namely printed and non-printed teaching materials. Examples of printed teaching materials comprise of books, documents, modules, brochures, and student's worksheets. While non-printed teaching materials include audio teaching materials, such as cassettes, radio, LPs, and compact disks as well as e-books. One that can be accessed by students anywhere and anytime is a digital book or e-book (Aydin & Aytekin, 2018). E-books are one of the suitable teaching materials integrated with the STEM approach. This is in accordance with research conducted by Andaresta (2021) which states that the application of STEM-based e-books in learning does not only emphasize mastery of concepts but trains scientific literacy (Andaresta, 2021).

The application of e-books with the STEM approach in increasing scientific literacy is not effective at all levels of education. This statement is proven based on research conducted by Ananda (2021) which states that STEM is most effectively used at senior high school level while for junior high school and elementary school it is less effective and based on research conducted by Putri (2022) the application of the STEM approach in learning is most effective at the elementary school and senior high school. Based on these two studies, there is a conflict between the effectiveness of using STEM integration in learning so that on this basis, it is necessary to analyze the effect size of the influence of STEM-based integrated Science e-books on students' scientific literacy so that the application of STEM in increasing students' scientific literacy is right on target. The formulation of the research problem is how to influence the use of STEM-based integrated Science e-books on students' scientific literacy in terms of educational level, types of teaching models and domains of learning outcomes. There are three objectives of this research. First, to see how much influence is exerted by the use of STEM-based integrated Science e-books in terms of education level. Second, to see how much influence is provided by the use of STEM-based integrated Science e-books reviewed from the initial model. Third, to see how much influence is exerted by the use of STEM-based integrated Science e-books on the realm of students' literacy learning outcomes

METHOD

Research meta-analysis was a method used to quantitatively review a number of previous studies. Due to the meta-analysis research, a quantitative approach was used. Analyzing quantitative data from previous research to determine whether the research hypothesis was valid or not becoming the basis for data analysis activities. The data to be analyzed came from several articles. The data collection was carried out by browsing several articles on online journal sites such as Google Scholar. The search was carried out using several keywords such as e-book, STEM, and scientific literacy. Based on these keywords, several articles related to the searched keywords appeared, then a selection was made of the articles that appeared. After that, choosing articles that met the criteria then selecting articles that met the criteria for the integrated Science e-book on STEM-based student science literacy.

The stages of meta-analysis research in outline, there were five stages of meta-analysis, as follows: first, defining the problem. Second, collecting available literature. Third, converting and correcting the statistical data. Fourth, determining the typical information obtained. Fifth, taking into account the various effects observed. The size of the influence of a variable on other variables is the size of the effect. Using statistical data from each journal, a conversion formula can be used to calculate effect sizes.

Table 1. Effect Size Determination

No.	Statistics	Formula
1.	The effect size formula for the two-sample comparison test related to the pretest-posttest mean and pretest-posttest standard deviation	$ES\ (d) = \frac{\bar{X}_{post} - \bar{X}_{pre}}{SD_{within}}$ $SD_{within} = \sqrt{\frac{SD_{Pretest^2} - SD_{Posttest^2}}{2}}$
2.	The effect size formula for a comparison test of two independent samples. Used if it was known only the posttest data from the mean and standard deviation of the two sample groups.	$ES\ (d) = \frac{\bar{X}_E - \bar{X}_C}{SD_{within}}$ $SD_{within} = \sqrt{\frac{(n_E - 1)SD_{E^2} + (n_c - 1)SD_{C^2}}{n_E + n_{c^{-2}}}}$

No.	Statistics	Formula
3.	The effect size formulas for two independent sample groups for the posttest pretest mean scores and the pretest standard deviation for the experimental class were known, the pretest posttest mean scores, pretest standard deviations and posttest control groups were known	$ES = \frac{(\bar{X}_{post} - \bar{X}_{pre})_E - (X_{post} - \bar{X}_{pre})_C}{SD_{within}}$ $SD_{within} = \sqrt{\frac{(n_E-1)SD_{preE^2} + (n_c-1)SD_{preC^2} + (n_E-1)SD_{postE^2} + (n_c-1)SD_{postC^2}}{2(n_E + n_c-2)}}$
4.	t count	$ES = t\sqrt{\frac{1}{n_E} + \frac{1}{n_C}}$
5.	To obtain the d variance for the two groups	$Vd = \frac{nE + nC}{nEnC} + \frac{d^2}{2(nE + nC)}$
6.	Variance value d for one group data	$Vd = \frac{1}{n} + \frac{d^2}{2(n)}$
7.	Standard error of d	$SEd = \sqrt{Vd}$
8.	The correction factor was J	$J = 1 - \frac{3}{4df - 1}$ The df values for the two independent groups viz df = nE + nc − 2 . df value for one group ie df = n −1.
9.	Effect size value	$g = J \text{ x } d$
10.	Variance value	$\text{V}g = J^2 \text{ x } Vd$
11.	Standard error	$SEg = \sqrt{Vg}$

(Becker, 2011).

Table 2. Effect Size Determination Summary Fixed Effect Model

No.	Statistics	Formula
1.	Fixed effect model	$M = \frac{\sum_{i=l}^{k} W_i Y_i}{\sum_{i=l}^{k} W_i}$ Where, $W_i = \frac{1}{VY_i}$
2.	Effect variance (VM)	$V_M = \frac{1}{\sum_{i=l}^{k} W_i}$
3.	Standard error effect (SEM)	$SE_M = \sqrt{V_M}$
4.	Lower limit (LLM) and Upper limit (ULM)	$LL_M = M - 1.96\ x\ SE_M$ $UL_M = M + 1.96\ x\ SE_M$
5.	Test the hypothesis by calculating the value of Z	$Z = \frac{M}{SE_M}$ p – value one – tailed test: $p^* = 1 - \phi\ (\pm \lvert Z^* \rvert)$ p – value two – tailed test: $p^* = 2[1 - \phi\ (\pm \lvert Z^* \rvert)$

Table 3. Determination of Effect Size Random Effect Model

No.	Statistics	Formula
1.	Random effect model	$T^2 = \frac{Q - df}{C}$ Q represented the variability between study means (a measure of heterogeneity). $Q = \sum_{i=l}^{k} (W_i Y_i)^2 - \frac{\sum_{i=l}^{k} (W_i Y_i)^2}{\sum_{i=l}^{k} W_i}$ Where, $C = \sum_{i=l}^{k} W_i - \frac{\sum_{i=l}^{k} W_i^2}{\sum_{i=l}^{k} W_i}$ And, $W_i = \frac{1}{V_{yi}}$ $df = k - 1$
2.	Significant or heterogeneous differences in effect size	$I^2 = maximum\ (0, \frac{Q - df}{Q}$ X 100%
3.	Weighted mean effect (M*)	$M^* = \frac{\sum_{i=l}^{k} W_i^* Y_i}{\sum_{i=l}^{k} W_i^*}$ Where, $W_i^* = \frac{1}{V^* Y_i}$ And, $V^* Y_i = V_{yi} + T^2$

No.	Statistics	Formula
4.	Standard error effect (SEM*)	$SE_{M^*=\sqrt{VM^*}}$
5.	Lower limit (LLM*) and Upper limit (ULM*)	$LL_{M^*} = M^* - 1.96\ x\ SE_{M^*}$ $UL_M^* = M^* + 1.96\ x\ SE_M^*$
6.	Calculating the value of Z to test the null hypothesis (H0 : true effect θ = 0)	$Z = \frac{M^*}{SE_{M^*}}$ p – value one – tailed test : p* = 1 -ϕ (± | Z* |) p – value two – tailed test : p* = 2[1 -ϕ (| Z* |)]

Table 4. Category of Securities Size Value

No.	Effect Size	Category
1.	ES ≤ 0,15	Very low
2.	0,15 < ES ≤ 0,40	Low
3.	0,40 < ES ≤ 0,75	Medium
4.	0,75 < ES ≤ 1,10	High
5.	ES≥1,45	Very high

(Dincer, 2015)

RESULTS & DISCUSSION

Results

This research examines how the STEM-based integrated Sciences e-book affects students' science literacy by reviewing and analyzing several past studies. The data to be analyzed comes from several relevant articles of the last 5 years with articles that also help in determining the effect size of the articles. Data was collected by researchers from various sources, including Google Scholar and others. A total of 20 journals were selected based on certain criteria. The search was carried out using several keywords such as e-book, STEM, and scientific literacy. Based on these keywords, several articles related to the searched keywords appeared, then a selection was made of the articles that appeared. After that, selecting articles that met the criteria for analysis.

Processing Effect Size on Each Article

Based on the research that has been carried out, the results obtained from data processing were carried out to see the results of the effect size and summary effect size of the influence of the STEM-based integrated Sciences e-book on students' scientific literacy based on class level, learning material, learning model and approach used. There are three parts to the results of the calculation of the 20 journals mentioned above. First, the influence of integrated science e-books on the students' science literacy. Second, the influence of the integrated science e-book based on the level of education. Third, the influence of the integrated science e-book based on the class level. Fourth, the effect of integrated science

e-books based on the learning models and approaches. Article codification as shown in Table 5 below.

Table 5. Processing Effect Size of Each Article

Processing Effect Size of Each Article								
Article Code	D	Vd	Sed	df	J	g(Yi) (*Effect Size*)	Vg (Vyi)	Seg
A1	1.65	0.08	0.29	62	0.99	1.63	0.24	0.49
A2	3.1	0.09	0.29	102	0.99	3.08	0.09	0.29
A3	5.7	0.20	0.44	102	0.99	5.66	0.19	0.44
A4	0.4	0.06	0.25	62	0.99	0.39	0.06	0.25
A5	0.96	0.07	0.27	62	0.99	0.95	0.07	0.26
A6	0.06	0.07	0.26	60	0.98	0.06	0.06	0.25
A7	1.17	0.07	0.27	62	0.99	1.16	0.07	0.27
A8	0.72	0.07	0.26	62	0.99	0.71	0.07	0.26
A9	0.23	0.06	0.04	62	0.99	0.23	0.06	0.25
A10	0.11	0.07	0.26	58	0.99	0.13	0.07	0.26
A11	0.24	0.34	0.59	10	0.92	1.16	0.29	0.53
A12	5.8	0.35	0.59	58	0.99	5.73	0.34	0.59
A13	1.72	0.07	0.26	62	0.99	1.70	0.07	0.26
A14	1.95	2.82	1.68	64	0.99	1.93	2.75	1.66
A15	0.71	0.06	0.25	62	0.99	0.68	0.06	0.25
A16	1.29	0.07	0.26	69	0.99	1.28	0.07	0.26
A17	0.72	0.26	0.51	48	0.98	0.71	0.25	0.50
A18	0.81	0.50	0.71	156	1.00	0.80	0.50	0.70
A19	2.2	1.10	1.05	48	0.98	2.17	1.07	1.03
A20	0.91	0.41	0.64	62	0.99	0.89	0.40	0.63

Based on the processing of the effect size of each article, the table illustrates the size of each study on how students' scientific literacy is affected by using integrated STEM-based Science books. In general, the result of the average effect size of using STEM-based integrated Science e-books with an average of 1.55, students get very high ratings in the category of scientific literacy. This shows that STEM-based integrated science e-books can increase students' scientific literacy. Also according to research of Agustin et al., (2019) that the use of teaching materials such as e-books can increase students' understanding of the nature of Science. The nature of Science itself is the aspects contained in the dimensions of scientific competence, as well as scientific knowledge, all of which are components of scientific literacy.

Effect of STEM-Based Integrated Science E-books on Student Science Literacy

a. Heterogeneity Testing

The summary effect size of the effect of STEM-based integrated science e-books on scientific literacy is obtained by testing heterogeneity first. Testing the heterogeneity of the articles was carried out in order to obtain a Q value that would be used in determining the model to be used to calculate the summary effect size. Testing heterogeneity on the

effect of STEM-based integrated science e-books on scientific literacy can be seen in Table 6.

Table 6. Testing Student Science Literacy Heterogeneity

Testing Students' Scientific Literacy Heterogeneity						
Article Code	Effect Size (Yi)	Variance (Vyi)	Weight Wi	Wi^2	WiYi	$WiYi^2$
A1	1.63	0.24	4.10	16.80	6.68	44.68
A2	3.08	0.09	11.24	126.25	34.58	1196.07
A3	5.66	0.19	5.21	27.13	29.48	869.02
A4	0.39	0.06	15.87	251.95	6.19	38.32
A5	0.95	0.07	14.71	216.26	13.94	194.36
A6	0.06	0.06	15.87	251.95	0.94	0.88
A7	1.16	0.07	14.08	198.37	16.31	266.01
A8	0.71	0.07	15.38	236.69	10.95	119.99
A9	0.23	0.06	16.39	268.74	3.77	14.22
A10	0.13	0.07	15.38	236.69	2.00	4.00
A11	1.16	0.29	3.50	12.23	4.06	16.48
A12	5.73	0.34	2.92	8.50	16.72	279.46
A13	1.70	0.07	15.38	236.69	26.08	680.01
A14	1.93	2.75	0.36	0.13	0.70	0.49
A15	0.68	0.06	16.39	268.74	11.20	125.37
A16	1.28	0.07	14.93	222.77	19.09	364.41
A17	0.71	0.25	3.95	15.62	2.80	7.83
A18	0.80	0.50	2.02	4.08	1.62	2.61
A19	2.17	1.07	0.94	0.88	2.03	4.12
A20	0.89	0.40	2.50	6.25	2.24	5.00
	Amount		191.13	2606.72	211.37	4233.32
	Q			4211.17		
	C			177.49		
	df			19		
	T^2			23.62		
	I^2			99.55%		

Based on the heterogeneity test, it is found that Q > df, then the estimation of the variance between articles is quite large and the data is heterogeneous. The model that is suitable for calculating summary effect sizes is the random effects model. The heterogeneity value of the article data is 99.95%, indicating that there is a population difference between articles of 99.95%.

b. Hypothesis test

Based on the results of the heterogeneity testing that has been carried out, it is known that the random effects model is most suitable to be used to calculate the summary effect size of the effect of STEM-based e-books on students' scientific literacy. Calculation of the summary effect size on students' scientific literacy can be seen in Table 7.

Table 7. Testing Students' Scientific Literacy Hypothesis

Testing Students' Scientific Literacy Hypothesis						
Article Code	Effect Size (Yi)	Variance (Vyi)	Variance Between Articles (T^2)	Total Variance ($Vyi+T^2$)	Weight Wi*	(Wi*.Yi)
A1	1.63	0.24	23.62	23.86	0.04	0.07
A2	3.08	0.09	23.62	23.71	0.04	0.13
A3	5.66	0.19	23.62	23.81	0.04	0.24
A4	0.39	0.06	23.62	23.68	0.04	0.02
A5	0.95	0.07	23.62	23.69	0.04	0.04
A6	0.06	0.06	23.62	23.68	0.04	0.00
A7	1.16	0.07	23.62	23.69	0.04	0.05
A8	0.71	0.07	23.62	23.68	0.04	0.03
A9	0.23	0.06	23.62	23.68	0.04	0.01
A10	0.13	0.07	23.62	23.68	0.04	0.01
A11	1.16	0.29	23.62	23.90	0.04	0.05
A12	5.73	0.34	23.62	23.96	0.04	0.24
A13	1.70	0.07	23.62	23.68	0.04	0.07
A14	1.93	2.75	23.62	26.37	0.04	0.07
A15	0.68	0.06	23.62	23.68	0.04	0.03
A16	1.28	0.07	23.62	23.69	0.04	0.05
A17	0.71	0.25	23.62	23.87	0.04	0.03
A18	0.80	0.50	23.62	24.11	0.04	0.03
A19	2.17	1.07	23.62	24.69	0.04	0.09
A20	0.89	0.40	23.62	24.02	0.04	0.04
		Amount			0.84	1.29
		M*			1.55	
		VM*			1.20	
		SEM*			1.09	
		LLM*			-0.45	
		ULM*			3.84	
		Z*			1.41	
		p-value one-tailed test			0.00	
		p-value two-tailed test			0.00	

Based on the results of hypothesis calculations on students' scientific literacy, it was found that from the 20 articles used, it was shown that the STEM-based integrated Science e-book had an influence on students' scientific literacy. The results of the weighted summary effect size obtained were 1.55 indicating that STEM-based e-books were in the very high category, with confidence intervals below -0.45 and above 3.84. The results of hypothesis testing also show that the p value $<\alpha$, which indicate that the hypothesis testing H0 is rejected. The results of H0 being rejected indicate that as many as 20 similar articles have the effect of STEM-based integrated Science e-books on students' scientific literacy.

Effect of STEM-Based Integrated Science E-Books Based on Education Level

a. Heterogeneity Testing

The effect size of the influence of STEM-based integrated science e-books on scientific literacy is obtained by testing heterogeneity first. Testing the heterogeneity of the articles was carried out in order to obtain a Q value that would be used in determining the model to be used to calculate the summary effect size. Testing heterogeneity on the influence of STEM-based integrated science e-books on scientific literacy based on the moderator variable, namely the level of education. There is 1 article that discusses the STEM-based integrated Science e-book on Science literacy at the elementary level, 9 articles for the middle school level, 9 articles for the high school level and 1 article for the college level. Testing the heterogeneity of the effect of STEM-based integrated Science e-books on scientific literacy at the education level can be seen in Table 8.

Table 8. Heterogeneity Testing at Education Level

Education level	Article Code	Q	df	I^2
Junior high school	A4			
	A5			
	A6			
	A7			
	A8	17.62	8	55%
	A9			
	A10			
	A17			
	A18			
Senior high school	A1			
	A2			
	A11			
	A12			
	A13	71.06	8	89%
	A14			
	A16			
	A19			
	A20			

The heterogeneity of the two educational levels tested, namely junior high and high school, is known from the findings presented in Table 8. It was found that the junior high and high school levels showed a value of Q > df, so the estimation of the variance between articles was quite large and the data was heterogeneous. The model that is suitable for calculating summary effect sizes at the junior and senior high school education levels is the random effects model.

b. Hypothesis test

Based on the results of the heterogeneity testing that has been carried out, it is known that the random effect model is most suitable for calculating the summary effect size of the effect of STEM-based e-books on students' scientific literacy at the education level. The summary effect size calculation for students' scientific literacy at the education level can be seen in Table 9.

Table 9. Hypothesis Testing at Education Level

Education level	Article Code	Effect Size	SEM*	LLM*	ULM*	Z*	*p*
Junior high school	A4						
	A5						
	A6						
	A7						
	A8	0.58	0.06	-0.08	-0.14	9.75	0.0
	A9						
	A10						
	A17						
	A18						
Senior high school	A1						
	A2						
	A11						
	A12						
	A13	2.18	0.31	0.01	1.21	6.42	1.0
	A14						
	A16						
	A19						
	A20						

Based on the results of testing the hypothesis at each level of education, it shows that all students' scientific literacy is influenced by their level of education. At junior high school education level, the effect size is in the medium category with an average junior high school level of 0.58. Whereas for senior high school level, it has a category with a very large effect size with an average senior high school level of 2.18.

The results of hypothesis testing at junior and senior high school levels show that the p value > α, which indicates that the hypothesis testing H0 is accepted. The results of testing the hypothesis obtained also show that at senior high school education level it does not have an effect on students' scientific literacy. The results of testing the hypothesis at junior high school education level show that the p value <α, showing that the hypothesis testing H0 is rejected. These results indicate that junior high school affects students' scientific literacy.

The Effect of STEM-based Integrated Science E-Books Based on Subject Matter

a. Heterogeneity Testing

Subsequent results from this research related to the influence of STEM-based integrated Science e-books on students' scientific literacy based on learning materials. The summary effect size value of the influence of STEM-based integrated Science e-books on scientific literacy based on learning materials was obtained through the initial stage, namely testing the heterogeneity of each learning material. Testing the heterogeneity of the articles was carried out in order to obtain a Q value that would be used in determining the model to be used to calculate the summary effect size. Testing the heterogeneity of the influence of STEM-based integrated Science e-books on sin literacy can be seen in Table 10.

Table 10. Heterogeneity Testing on Learning Materials

Subject Matter	Article Code	Q	df	I^2
Impulse and Momentum	A1 A19	-0,98	1	202%
Biology	A2	-71,91	0	100%
Temperature and Heat	A3	-137,43	0	100%
Vibration and Waves	A4 A7 A9 A10 A11 A12 A17 A20	45,39	6	87%
Digestive Health	A5	0,72	0	100%
Motion	A6	0,88	0	100%
Pressure	A10	1,74	0	100%
Respiratory Health	A8	3,15	0	100%
Optical Tool	A13	-18,11	0	100%
Environmental pollution	A14 A16	19,76	1	95%
Inheritance	A18	0,33	0	100%

Table 10 shows that only three teaching materials were tested for heterogeneity because only three teaching materials have different populations. It was known from the results. The 3 learning materials tested for heterogeneity were impulse and momentum, vibration and waves, as well as environmental pollution, while the 8 other learning materials were not tested for heterogeneity because the population was the same.

Based on the results of heterogeneity testing on the 3 learning materials, it was found that the 7 learning materials showed a value of Q> df, so the estimation of the variance between articles was quite large and the data was heterogeneous. The model that is suitable for calculating summary effect sizes on 7 subject matter is the random effects model. Meanwhile, for the other 4 materials, namely impulse and momentum, Biology, temperature and heat, optical instruments use a fixed effect model.

b. Hypothesis test

The next stage is testing the hypothesis of the influence of STEM-based integrated Science e-books on students' scientific literacy based on learning materials. Based on the results of the heterogeneity testing that has been done, it is known that the random effects model is most suitable to be used to calculate the summary effect size of the influence of STEM-based integrated science e-books on students' scientific literacy. Calculation of hypotheses based on learning materials can be seen in Table 11.

Table 11. Hypothesis Testing Based on Learning Materials

Subject Matter	Article Code	Effect Size	SEM*	LLM*	ULM*	Z*	*P*
Impulse and Momentum	A1 A19	3.8	0,44	-0,10	2,60	3,92	0,00
Biology	A2	3.08	0,30	0,34	1,51	10,26	0,00
Temperature and Heat	A3	5.66	0,34	1,27	2,62	16,47	0,00
Vibration and Waves	A4 A7 A9 A10 A11 A12 A17 A20	10.4	0,34	-0,26	1,09	3,49	0,00
Digestive Health	A5	0.95	3,08	-3,12	8,96	0,31	0,38
motion	A6	0.06	0,00	0	0	0,00	0,5
Pressure	A10	0.13	0,00	0	0	0,00	0,5
Respiratory Health	A8	0.71	0,00	0	0	0,00	0,5
Optical Tool	A13	1.7	0,00	0	0	0,00	0,5
Environmental pollution	A14 A16	3.21	5,40	6,75	27,92	0,60	0,28
Inheritance	A18	0.8	40,66	-47,16	0	0,02	0,49

Based on the results of testing the hypothesis on learning materials, it is found that the 11 existing learning materials show an effect on scientific literacy skills. The results of the calculation of the effect size show that 6 learning materials are in the very high category, 2 learning materials are in the high category, 1 learning material is in the medium category, and 2 materials are in the very low category. Table 11 also shows the results of hypothesis testing, namely the value of $p < \alpha$ in 4 learning materials, then testing the H0 hypothesis is rejected. The results of testing this hypothesis also show that 4 learning materials, namely momentum and impulse, Biology, temperature and heat, as well as vibration and waves using the STEM-based integrated Science e-book have an effect on scientific literacy.

Discussion

This research is conducted to see the effect of using STEM-type integrated Science e-books on students' scientific literacy skills obtained from as many as 20 articles. The article contains various cohesiveness models used in e-books. The results of this research are reviewed from 2 aspects. First, it is reviewed based on the scientific literacy of students at the educational level. The second is in terms of the learning materials used. In this research, first, it was determined how much influence the STEM-type integrated Science E-book had on students' scientific literacy abilities in general. Based on the results it was found that the average effect size was in the very high category, which means that the STEM-type integrated science E-book has an effect on students' scientific literacy. This is

in line with research conducted by Izzah (2021) who tested the effect size of Science and Physics teaching materials with the STEM approach were in the high category so that it could strengthen the statement that students' scientific literacy could be influenced by the use of STEM-type Science e-books in Science learning.

Based on the overall average effect size it is said that the STEM-based integrated Science e-book has a strong influence on scientific literacy. However, when analyzing one by one, not all articles state that the STEM-based integrated Science e-book have a strong effect on students' scientific literacy. This statement is proven by the effect size results in articles A6 and A10 which are in the very low category, A4 and A9 are in the low category and A8, A15 and A17 are in the medium category, which means that the results of research based on these articles show that the integrated Science e-book STEM-based science does not affect students' scientific literacy and the research results of these articles are very different from other articles which state that STEM-based integrated science e-books have a strong influence on scientific literacy.

To find out the cause of the difference in effect size results in articles that are in the very low to very high categories, analysis is carried out in 2 categories, namely heterogeneity testing and hypothesis testing. The heterogeneity test is the basis for decision making to accept or to reject homogeneity. Based on the results of the heterogeneity test, it is found that $Q \geq df$, which means that the assumption of homogeneity needs to be rejected and accepts the assumption of heterogeneity, which means that conclusions are drawn using a random effect model. Based on the results of calculations using the random-effect model, it is found that the confidence interval contains 0 (zero), it is evident that the treatment given to the group of students in the form of using the STEM type Science e-book is not different from the group of students being taught without the STEM type e-book in terms of increasing students' scientific literacy so that it can be concluded that neither the application of the e-book to every type of population nor the application of the STEM E-book shows the effectiveness of the STEM-type Science e-book on scientific literacy. The reason is that based on research conducted by Hannikah (2022), it is found that e-books used in learning are not always effective because printed books are more comfortable to read for a long time when compared to e-books. Reading an e-book requires the reader to stare at the screen of an electronic device that emits uncontrolled radiation and lighting.

To find out more about the problem of not having an effect on the STEM-based integrated Science e-book on students' scientific literacy in general, a categorization of STEM use is carried out into 2 categories, namely education level and subject matter. The first category, namely the education level, carrying out 2 types of tests, namely heterogeneity and homogeneity. Based on the heterogeneity test results obtain $Q \geq df$, which means that the assumption of homogeneity is rejected and accepts the assumption of heterogeneity. Based on the heterogeneity test, the value of $I^2 > 25\%$ is also obtained, which further confirms that the conclusion is drawn using a random effect model. Based on the results of the random effect model, it is found that the value of $p > \alpha$ for Senior high school means that there is no difference in the effectiveness of STEM-based integrated Science e-books and those who do not use STEM-based integrated Science e-books at senior high school level, while junior high school has $p \leq \alpha$, meaning that there is a difference in the effectiveness of E STEM-based integrated Science books with non-STEM-based integrated Science e-books for universities. This fact is consistent with research conducted by Tanjung (2022) where in his research it is found that STEM-based Science learning for tertiary institutions is in the high category, which means it is effective in increasing students' scientific literacy while junior high schools are in the medium category.

The reason is that the e-book is integrated with sound shows, pictures, animations, games, learning videos, and so on, so that the information presented is more varied, and

can visualize abstract material requiring accurate analysis and this statement is in line with the research conducted by Nurhayati (2017) middle and high school, which are classified as teenagers, children are able to think abstractly like adults but are not yet perfect, meaning that even though they can be applied to both levels of education, they still need other supporting factors to help translate abstract concepts such as teaching materials, good preparation from the teacher and the conditions that allow for the STEM approach. The application of STEM-based integrated Science e-books is more effective at the junior high school level because the curriculum applied to junior high schools combines Physics, Biology and Chemistry as well as technology in one subject while senior high schools do not combine subjects. In this problem, it can also be seen that learning Science which is separated is less efficient in increasing scientific literacy because the achievements in each subject are different, interrelated science subjects in high school will also cause problems of subject confusion and insufficient lesson time efficiency considering the achievements each science subject in high school is very complex.

The explanation above is in accordance with the characteristics of the curriculum implemented in junior high schools, namely integrated Science learning carried out without separating the sub-disciplines such as Biology, Chemistry and Physics and connecting them with technology and the characteristics of the junior high school curriculum according to the STEM learning approach which combines 4 disciplines of knowledge namely Science, Technology, Engineering and Mathematics (Ministry of National Education, 2011). This integration causes students to gain a complete understanding so that their learning outcomes become more optimal (Oktavia, 2018). At the high school level, Physics, Chemistry and Biology are separated by different learning outcomes and very complex material, and at the high school level, Science teachers are divided into separate Science learning fields (Physics, Chemistry and Biology) with heavy material content (Ichsan, Dewi, Hermawati, & Iriani, 2018). Science material that is separated at the high school level makes integrated Science e-books that combine Science fields difficult to apply in high school and heavy material when science fields are separated and combined with the STEM approach makes it even more difficult for students to understand it so that it can be said that Science e-books integrated with the STEM approach are lacking more effective in high school than in middle school.

The second category is subject matter. In the second category, 2 types of tests are carried out, namely heterogeneity and homogeneity. Based on the heterogeneity test results obtained $Q \geq df$, which means that the assumption of homogeneity is rejected and accepts the assumption of heterogeneity. Based on the heterogeneity test, the value of $I^2 > 25\%$ is also obtained, which further confirms that the conclusion is drawn using a random effect model. Based on the results of the random effect model, it was found that the value of $p < \alpha$ in the e-book with material on temperature and heat, Biology, vibration and waves as well as momentum and impulse so that the e-book on these three materials can increase students' scientific literacy. The cause is momentum and impulse material as well as Biology including Physics material which is not abstract, meaning it can be understood more easily. While the material temperature and heat as well as waves including material that is abstract. The existence of Science material that is abstract in nature such as temperature and heat and waves makes it difficult for students to learn it (Marsya, Yuniasti, & Wulandari, 2022). So to learn it requires the help of the media. Even so, the material on temperature and heat and waves has many learning resources ranging from learning videos, virtual labs that increase understanding and are close to the environment (Nurdiansah, 2020). Through STEM learning, students have scientific and technological literacy skills that can be seen from reading, writing, observing, and doing Science so that they can be used as provisions for living in society and solving problems faced in everyday life related to the STEM field of Science.

CONCLUSION

Based on the results of the analyzed data, it can be concluded that: 1) integrated Science e-books containing effective literacy do not always affect students' scientific literacy skills. 2) Based on the level of education, STEM-type integrated Science e-books at the high school education level have a p greater than α while at the junior high school education level the p is less than α, which means that STEM-type Science e-books are more effective for increasing scientific literacy in junior high schools. 3) Based on the subject matter, temperature and heat, vibration and waves and momentum and impulses as well as Biology are effective for increasing students' scientific literacy because the p value is smaller than α which means STEM-type Science e-books are more effective for increasing scientific literacy if used in the four materials.

REFERENCES

Agustin, L., Widodo, W., & Purnomo, A. R. (2019). Penggunaan interactive e-book IPA untuk meningkatkan literasi sains pada materi energi dan metabolisme sel. *E-Jurnal Pensa*, *7*(2), 268–273. Retrieved from https://ejournal.unesa.ac.id/index.php/pensa/article/view/28580

Ananda, P. N., & Salamah, U. (2021). Meta analisis pengaruh integrasi pendekatan STEM dalam pembelajaran IPA terhadap kemampuan berpikir kritis peserta didik. *Jurnal Penelitian Pembelajaran Fisika*, 7(1), 54–64. Retrieved from https://doi.org/10.24036/jppf.v7i1.111634

Andaresta, N. (2021). Pengembangan e-book berbasis STEM pada materi ekosistem untuk melatihkan kemampuan literasi sains siswa [Development of STEM-based e-books on ecosystem materials to practice students' scientific literacy skills]. *BioEdu*, 10(1), 635–646. https://doi.org/10.26740/bioedu.v10n3.p635-646

Asrizal, A., & Dewi, W. S. (2019). Pengaruh bahan ajar IPA tema kesehatan pernapasan dan ekskresi manusia mengintegrasikan keterampilan belajar terhadap kompetensi siswa kelas VIII di SMPN 7 Padang. *Pillar of Physics Education, 12*(3). http://dx.doi.org/10.24036/6615171074

Astini, N. W., & Purwati, N. K. R. (2020). Strategi pembelajaran matematika berdasarkan karakteristik siswa sekolah dasar. *Jurnal Edukasi Matematika Dan Sains*, 9(1), 1–8. Retrieved from http://repo.mahadewa.ac.id/id/eprint/1776/1/621-Article Text-1614-1-10-20200503.pdf

Aydin, A., & Aytekin, C. (2018). Teaching materials development and meeting the needs of the subject: a sample application. *International Education Studies*, *11*(8), 27–38. https://doi.org/10.5539/ies.v11n8p27

Banila, L., Lestari, H., & Siskandar, R. (2021). Penerapan blended learning dengan pendekatan STEM untuk meningkatkan kemampuan literasi sains siswa pada pembelajaran biologi di masa pandemi covid-19. *Journal of Biology Learning*, 3(1), 25. Retrieved from https://doi.org/10.32585/jbl.v3i1.1348

Berliana, A. U., Mailizar, M., Faiza, F., & Leonard, L. (2021). Pengembangan media pembelajaran berbasis android melalui model pembelajaran PAIKEM (pembelajaran aktif, inovatif, kreatif, dan menyenangkan). *Journal of Instructional Development Research, 2*(2), 57–68. https://doi.org/10.61193/jidr.v2i2.14

Depdiknas. 2011. Standar I*si Untuk Satuan Pendidikan Dasar dan Menengah*. Jakarta: Dirjen Dikti Depdiknas

Febrina, T., Leonard, L., & Astriani, M. M. (2020). Pengembangan modul elektronik matematika berbasis web. *JKPM (Jurnal Kajian Pendidikan Matematika), 6*(1), 27-36. http://dx.doi.org/10.30998/jkpm.v6i1.8141

Fuadi, H., Robbia, A. Z., Jamaluddin, J., & Jufri, A. W. (2020). Analisis faktor penyebab rendahnya kemampuan literasi sains peserta didik. *Jurnal Ilmiah Profesi Pendidikan*, 5(2), 108–116. Retrieved from https://doi.org/10.29303/jipp.v5i2.122

Hanikah, H., Faiz, A., Nurhabibah, P., & Wardani, M. A. (2022). Penggunaan media interaktif berbasis ebook di sekolah dasar. *Jurnal Basicedu*, 6(4), 7352–7359. Retrieved from https://doi.org/10.31004/basicedu.v6i4.3503

Hayati, N., & Afrizon, R. (2019). Dampak buku ajar IPA terpadu bermuatan literasi saintifik tema kesehatan pencernaan dalam model pembelajaran kontekstual adaptif pada hasil belajar siswa kelas VIII SMPN 7 Padang. *Pillar of Physics Education, 12*(1). http://dx.doi.org/10.24036/4935171074

Ichsan, I. Z., Dewi, A. K., Hermawati, F. M., & Iriani, E. (2018). Pembelajaran IPA dan lingkungan: analisis kebutuhan media pembelajaran pada SD, SMP, SMA di Tambun Selatan, Bekasi. *JIPVA (Jurnal Pendidikan IPA Veteran)*, 2(2), 131. Retrieved from https://doi.org/10.31331/jipva.v2i2.682

Izzah, N., Asrizal, A., & Festiyed, F. (2021). Meta analisis effect size pengaruh bahan ajar IPA dan fisika berbasis STEM terhadap hasil belajar siswa. *Jurnal Pendidikan Fisika*, 9(1), 114. Retrieved from https://doi.org/10.24127/jpf.v9i1.3495

Jowsey, T., Foster, G., Cooper-Ioelu, P., & Jacobs, S. (2020). Blended learning via distance in pre-registration nursing education: A scoping review. *Nurse Education in Practice*, 102775. https://doi.org/10.1016/j.nepr.2020.102775

Ling, L. S., Pang, V., & Lajium, D. (2019). The planning of integrated STEM education based on standards and contextual issues of Sustainable Development Goals (SDG). *Journal of Nusantara Studies (JONUS)*, *4*(1), 300–315. http://dx.doi.org/10.24200/jonus.vol4iss1pp300-315

Mardianti, F., Yulkifli, Y., & Asrizal, A. (2020). Metaanalisis pengaruh model pembelajaran inkuiri terhadap keterampilan proses sains dan literasi saintifik. *Sainstek: Jurnal Sains Dan Teknologi*, *12*(2), 91–100. http://dx.doi.org/10.31958/js.v12i2.2435

Marsya, A., Syafi'i, A., & Wulandari, A. Y. R. (2022). Efektivitas pendekatan stem pada materi pesawat sederhana terhadap hasil belajar peserta didik. *Natural Science Education Research, 5*(1), 135-141. https://doi.org/10.21107/nser.v5i1.15760

Mukharomah, F., Wiyanto, W., & Putra, N. M. D. (2021). Analisis kemampuan literasi sains fisika siswa SMA pada materi kinematika gerak lurus. *Journal of Teaching and Learning Physics*, *6*(1), 11–21. https://doi.org/10.15575/jotalp.v6i1.10391

Ningkaula, T. A., Laliyo, L. A. R., Iyabu, H., & Abdullah, R. (2021). Dampak model discovery learning berpendekatan stem terhadap pemahaman konsep hidrolisis garam siswa SMA. *Jurnal Pendidikan Kimia Indonesia*, 5(2), 76. Retrieved from https://doi.org/10.23887/jpk.v5i1.28871

Nurdiansah, I., Islami, F. H., & Nana. (2020). Penerapan model Poe2We terhadap pemahaman konsep fisika materi gelombang berjalan dan gelombang stasioner. *Edufisika: Jurnal Pendidikan Fisika*, 5(1), 16–22. Retrieved from http://jurnal.untad.ac.id/jurnal/index.php/EPFT/article/view/15737/11593

Nurhafizah, N., Asrizal, A., & Ramli, R. (2018). Pengaruh Lembar Kerja Siswa IPA Terpadu Tema Gelombang dalam Kehidupan Mengintegrasikan Keterampilan Literasi Terhadap Kompetensi Siswa Kelas VIII SMPN 8 Padang. *Pillar of Physics Education, 11*(3), 145-152. http://dx.doi.org/10.24036/3396171074

Nurhayati, N., & Angraeni, L. (2017). Analisis kemampuan berpikir tingkat tinggi mahasiswa (higher order thinking) dalam menyelesaikan soal konsep optika melalui model problem based learning. *Jurnal Penelitian & Pengembangan Pendidikan Fisika*, 3(2), 119–126. Retrieved from https://doi.org/10.21009/1.03201

OECD (2019), PISA 2018 Results (Volume I): What Students Know and Can Do, PISA, OECD Publishing, Paris, https://www.oecd-ilibrary.org/education/pisa-2018-results-volume-i_5f07c754-en

Oktavia, R. (2018). Mathematics (STEM) untuk Mendukung Pembelajaran IPA Terpadu. *Jurnal SEMESTA Pendidikan IPA*, 5(2), 32–36. Retrieved from http://semesta.ppj.unp.ac.id/index.php/semesta

Putri*, R. M., Asrizal, A., & Usmeldi, U. (2022). Metaanalisis efek pendekatan STEM pada literasi sains dan pemahaman konsep peserta didik di setiap satuan pendidikan. *Jurnal IPA & Pembelajaran IPA*, 6(1), 86–98. Retrieved from https://doi.org/10.24815/jipi.v6i1.23897

Rahman, A. A. (2022). Integrasi computational thinking dalam model EDP-STEM untuk meningkatkan kemampuan berpikir kritis siswa SMP. *Jurnal Didaktika Pendidikan Dasar*, 6(2), 575–590. Retrieved from https://doi.org/10.26811/didaktika.v6i2.409

Retnowati, S. (2020). The STEM approach: The development of rectangular module to improve critical thinking skill. *International Online Journal of Education and Teaching*, *7*(1), 2–15. Retrieved from http://iojet.org/index.php/IOJET/article/view/704

Rini, C. P., Dwi Hartantri, S., & Amaliyah, A. (2021). Analisis kemampuan literasi sains pada aspek kompetensi mahasiswa PGSD FKIP Universitas Muhammadiyah Tangerang. *Jurnal Pendidikan Dasar Nusantara*, 6(2), 166–179. Retrieved from https://doi.org/10.29407/jpdn.v6i2.15320

Sakti, I., Nirwana, N., & Defianti, A. (2022). Implementasi pembelajaran berbasis STEM pada mata kuliah kajian IPA-1 materi suhu dan kalor untuk meningkatkan literasi sains mahasiswa. *Jurnal Kumparan Fisika*, 5(2), 131–140. Retrieved from https://doi.org/10.33369/jkf.5.2.131-140

Sari, D. P., Asrizal, Gusnedi, & Mufit, F. (2019). Studi komparasi hasil belajar siswa sebelum dan sesudah penggunaan bahan ajar IPA terpadu bermuatan literasi saintifik tema pemanfaatan tekanan kelas VIII SMP N 31 Padang. *FIllar of Physics Education*, 12(3), 425–432. http://dx.doi.org/10.24036/6567171074

Widayoko, A., Latifah, E., & Yuliati, L. (2018). Peningkatan kompetensi literasi saintifik siswa SMA dengan bahan ajar terintegrasi STEM pada materi impuls dan momentum. *Jurnal Pendidikan: Teori, Penelitian, Dan Pengembangan*, 3(11), 1463–1467. http://dx.doi.org/10.17977/jptpp.v3i11.11767

Yulia, E., Asrizal, & Ramli. (2018). Pengaruh bahan ajar IPA terpadu tema gelombang dalam kehidupan bermuatan literasi era digital terhadap hasil belajar siswa kelas VIII SMP Negeri 8 Padang. *Pillar of Physics Education*, 11(2), 113–120. Retrieved from http://ejournal.unp.ac.id/students/index.php/pfis/article/view/3301/2534

Yuliana, R., & Asrizal. (2019). Pengaruh bahan ajar IPA terpadu bermuatan keterampilan literasi tema gerak dalam kehidupan sehari hari terhadap kompetensi siswa kelas VIII SMPN 8 Padang. *Pillar of Physics Education*, 12(2), 121–128. http://dx.doi.org/10.24036/4919171074