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The Effect of E-Module in Improving The Learning Outcomes of Secondary School Students in Science Learning : A- Meta Analysis

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ABSTRACT

Learning in the 21st century demands mastery of concepts and improvement of optimal learning outcomes. The use of technology provides convenience in supporting learning with the existence of electronic teaching materials. This study aims to see the impact of using e-modules in improving student learning outcomes in science learning. Meta-analysis methods are used to collect quantitative data to calculate the magnitude of the effect of each relevant study. The research involved searching national and international journals using Google Scholar and ERIC between 2019 and 2023. The results of the analysis showed that the influence of e-modules on student learning outcomes had an average effect size value of 1.11, which was included in the large category. It is based on 21 studies that have been collected. The results of the analysis of moderator variables on the year and subjects also showed a significant influence from these two aspects. Overall, the use of e-modules in improving student learning outcomes in high schools has a significant impact.

INTRODUCTION

In the face of significant global change, a basic competence that everyone must have, namely 21st century skills (Silber-Varod et al., 2019). These skills become an important chart for every student to master. These skills go beyond traditional academic knowledge and emphasize qualities such as critical thinking, creativity, communication, collaboration, and digital literacy (Khoiri et al., 2021; Nurkhin & Pramusinto, 2020). As technology continues to reshape industry and global interactions, individuals proficient in 21st-century skills can adapt to new challenges, solve complex problems, work effectively in diverse teams, and navigate the digital landscape with competence and ethical awareness. These skills are increasingly sought after by employers and are critical to personal and professional success in a dynamic, interconnected 21st-century society.

In supporting the mastery of 21st century skills, it is important to apply the right approach/model/technology in the learning process. The 21st century learning approach

focuses on the significance of developing critical thinking skills in solving challenges. Not only that, creativity in dealing with problems and cooperation between students is also a priority in encouraging learning (Panigrahi et al., 2018; Saragih et al., 2020). In addition, communication also has an infinite role in building deeper understanding. In addition, the presence of technology supports the mastery of the 21st century at this time.

The implementation of technology in learning is very necessary to support the learning process to be more optimal. The use of technology can play a major role in the course of learning. Advances in technology provide rapid access to information and communication, enriching the learning experience. Various media, such as e-learning, e-books, and websites, become effective means in supporting the learning process (Dhanil & Mufit, 2021; Mufit et al., 2023). With these various technologies, various forms of media are formed that support students in mastering learning skills (Asysyifa et al., 2019; Neswary & Prahani, 2022; Wulandari et al., 2021). Thus, technology has opened the door for students to learn more interactively and immersively.

Technological advances give birth to a variety of research in supporting physics learning. Because, technology encourages digital-oriented learning. This condition encourages the birth of various digital teaching materials, one of which is e-modules. In learning, e-modules are able to provide positive efe and have no effect in the process of supporting learning outcomes. Previous researchers have developed self-teaching materials such as e-modules and have reported varying impacts on their use. E-modules in science learning have been widely utilized and have mixed effects. E-modules are able to encourage students to think critically in physics learning (Desnita et al., 2022). In addition, e-modules support students' understanding of concepts through self-directed learning (Diansah & Asyhari, 2020). However, other studies have shown that the use of e-modules does not have a significant impact in supporting science learning (Kurniawan et al., 2019; Wijaya, 2021).

Various research effects related to the use of e-modules in learning need to be investigated further. Mapping similar studies related to the use of e-modules in science learning needs to be analyzed through meta-analysis. The meta-analysis aims to determine the effects of similar studies comprehensively. In addition, in the meta-analysis, analysis was also carried out on moderator variables. Therefore, this study aims to see the effect of using e-modules in science learning on improving the learning outcomes of senior high school students. In addition, the analysis of moderator variables is also carried out by year and subject.

METHODS

This study falls into the category of meta-analysis. Meta-analysis, which combines similar studies to evaluate the impact of these studies as a whole. Meta-analysis aims to obtain effect size values and test hypotheses from similar studies in order to reach conclusions from meta-analyses. The analyzed studies were obtained from the ERIC and Google Scholar databases. Keywords used in the search include e-modules, learning outcomes, physics, chemistry, and biology.

Study on the meta-analysis process through the stages of inclusion and exclusion. Data that meet the inclusion criteria of the study designation were used as meta-analysis data sources. The limitations of these studies include: 1) research time spans from 2019 to 2023, 2) studies written in English, 3) involving only physics, chemistry, and biology learning, 4) only

at the high school education level, 5) studies that present sufficient information to calculate effect size, such as number of samples, mean value, standard deviation, and t value.

Data from the study sought were analyzed based on 5 predefined criteria. Establishment of criteria as research standards in meta-analyses of experimental research studies. All analyzed data is obtained from databases spread across the internet. Based on the search results in the Google Scholar database, 416 studies were found, while in the ERIC database found 88 studies. After a selection process, 21 studies were found that met the criteria for meta-analysis and calculated the size of the effect.

In the calculation of effect size, tools such as Excel and JASP applications are used. Excel applications play a role in processing data until the discovery of effect size. Furthermore, JASP applications are used in meta-analysis analysis to identify variations and display forest plots. The formula applied to process data includes the number of samples, the average value, and standard deviation in the effect size calculation as in equations 1 and 2. If the study does not find the mean value and effect of size, it can be calculated using the value of the T test as in equation 3 (Rosenthal, 1986; Thalheimer & Cook, 2002).

$$d=\frac{\bar{x}_E-\bar{x}_C}{SD_W}\left(1-\frac{3}{4df-1}\right) \quad (1)$$

$$SD_W=\sqrt{\frac{(n_E-1)S_E^2+(n_C-1)S_C^2}{n_C+n_E-2}} \quad (2)$$

$$d=\frac{1}{\sqrt{n}}\times 100 \quad (3)$$

To interpret the effect size value, the effect size assessment range used is: d = 0.2 (Small), d = 0.5 (Medium), d = 0.8 (Large) (Cohen, 1992) and d = 2.0 (Very large) (Sawilowsky, 2009). Hypothesis testing on the size effect is based on the p-value of the data results obtained from the JASP application. If the p-value <0.005, then the null hypothesis is rejected. In this study, the null hypothesis in this meta-analysis was that there was no significant effect of the use of e-modules on the learning outcomes of high school students in similar studies.

RESULTS AND DISCUSSION

The results of the meta-analysis data were obtained from the inclusion and exclusion process of each similar article. The data obtained is data that is in accordance with the criteria for article determination. Search results from the Google Scholar and ERIC databases yielded 504 studies, but only 21 studies qualified for meta-analysis. Each study collected and analyzed similar data as a data source for meta-analysis. The results of this meta-analysis have been grouped by author, subject, year, effect size value (g), and standard deviation (SE).

Table 1. Characteristics of meta-analysis

Author	Subject	Year	g	SE
(Diansah & Asyhari, 2020)	Physics	2020	1.92	0.29
(Desnita et al., 2022)	Physics	2022	2.29	0.33
(Kurniawan et al., 2019)	Physics	2019	0.01	0.25
(Astalini et al., 2019)	Physics	2019	1.14	0.27

(Baring & Berame, 2022)	Physics	2022	1.11	0.24
(Asrizal, Ayu, et al., 2022)	Physics	2022	1.39	0.26
(Wijaya, 2021)	Physics	2021	-1.05	0.26
(Asrizal, Zan, et al., 2022)	Physics	2022	2.94	0.35
(Fradila et al., 2021)	Biology	2021	2.08	0.38
(Fajrida et al., 2021)	Biology	2021	1.42	0.27
(Darmaji et al., 2019)	Physics	2019	0.25	0.08
(Agustin et al., 2023)	Biology	2023	0.7	0.22
(Rahmatsyah & Dwiningsih, 2021)	Chemistry	2021	2.81	0.49
(Putri & Yerimadesi, 2022)	Chemistry	2022	0.47	0.17
(C. A. Dewi et al., 2022)	Chemistry	2022	1.25	0.16
(Linda et al., 2020)	Chemistry	2020	3.95	0.6
(Warlinda et al., 2022)	Chemistry	2022	0.13	0.07
(Haryanto & Rustana, 2021)	Physics	2021	0.49	0.18
(Mas-ud et al., 2021)	Physics	2021	0.3	0.13
(Hunaidah et al., 2022)	Physics	2022	0.32	0.18
(Sari & Ariswan, 2021)	Physics	2021	0.64	0.22

Table 1 shows 21 data from similar studies that passed the inclusion phase. The data is distributed from articles spread from 2019 to 2023. In 2019, 3 studies were obtained; In 2020, 2 studies were obtained; In 2021, 7 studies were obtained; In 2022, 8 studies were obtained; and in 2023, 1 study was obtained. The subject matter is spread over physics, chemistry, and biology. For the size effect value, it is symbolized by the letter g which is spread at values -1.05 to 2.94.

The results of the study data were tested through the JASP application. The data processed in the JASP application is the value of data distribution in the form of forest plots. The forest plot displays the position of each study compared to the average score of the studies obtained. The distribution of data is displayed in the form of dots in a range of negative, zero, and positive values. The forest plot data is presented in Figure 1.

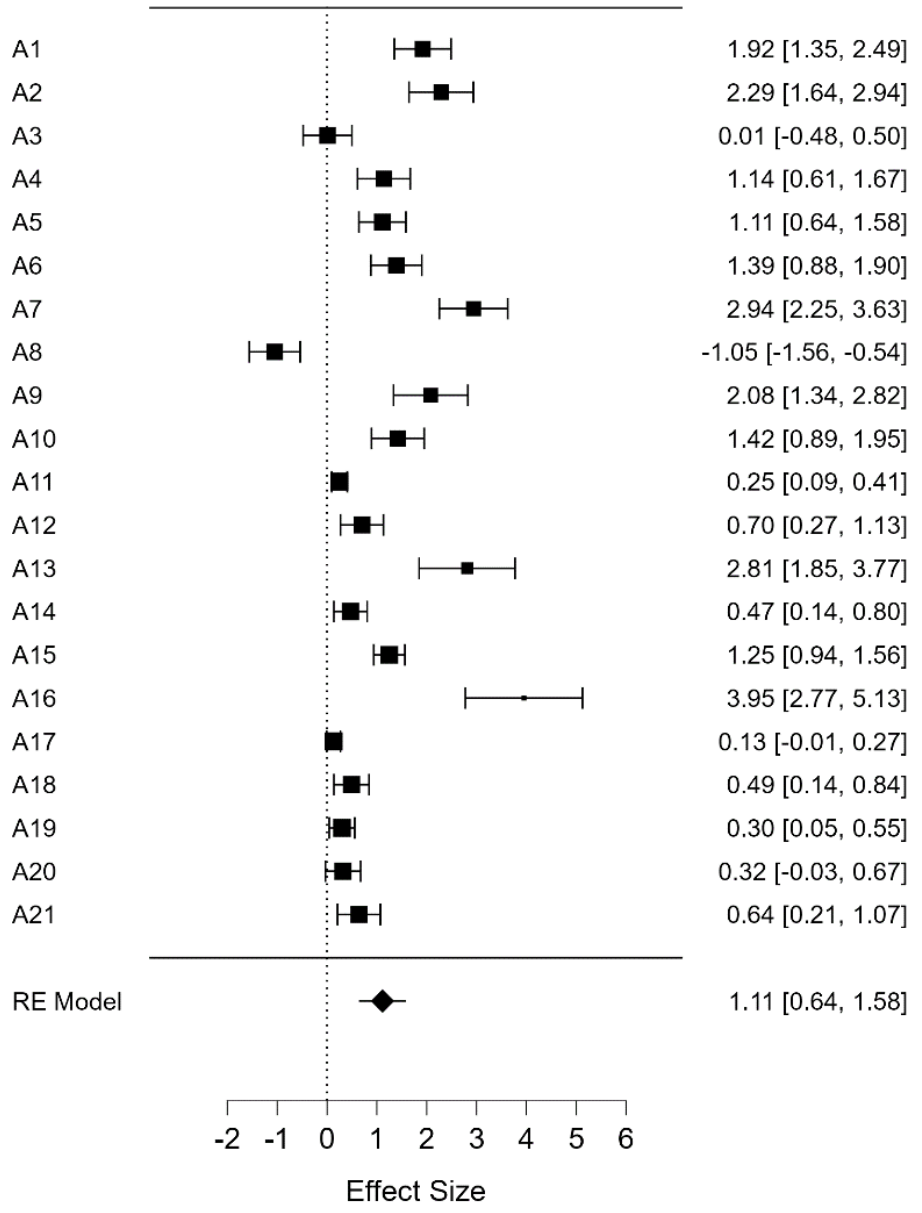

Figure 1. Forest plot

Based on table 1 and figure 1, Displays the characteristics and results of the distribution of size effects. The results of all effect sizes from 21 studies obtained an average value of 1.11. The value of the size effect is in the range of 0.64 to 1.58. The value of the effect of size and standard error is used to test heterogeneity and see the overall effect of using e-modlue through a hypothesis test. If the value is $p<0.05$ means the null hypothesis is accepted. The null hypothesis in this study is that there is a significant influence on the use of e-modules on the results of learning upper middle school students.

The data from the meta-analysis was carried out statistical testing in the form of value distribution. The test is obtained through heterogeneity testing. Heterogeneity testing was chosen because the data were spread over a diverse span of years and studies. The heterogeneity test result data generated from the JASP application displays the distribution of the number of samples, probability value, standard score, and effect size (g) value. Hypothesis testing from the data obtained from the heterogeneity test is the p value. All data obtained from heterogeneity tests are presented in Table 2.

Table 2. Heterogeneity test results

Variable	Overral	95% CI	
		Lower	Upper
Number of Sample (K)	21		
Heterogenity test (Q)	313.67		
Probability value (p)	<0.001	0.64	1.584
Standar score (z)	4.63		
Estimate (g)	1.114		
Heterogenity test (τ^2)	1.135	0.649	2.698
Heterogenity test (τ)	1.065	0.806	1.643
Heterogenity test (I^2 %)	97.255	95.300	98.827
Heterogenity test (H^2)	21		

Based on the results from Table 2, it can be seen that the value of heterogeneity has a p value of < 0.05, which means that the null hypothesis is acceptable. The value of the effect size obtained at 1,114 is in the large category. These results are supported by the results of the I^2 heterogeneity test which is a high size effect, showing that the results of the meta-analysis study obtained a score of 97,255% in the large category. Therefore, it can be concluded that the use of e-modules has a significant influence in improving student learning outcomes. Furthermore, the results of the heterogeneity test allow for moderator variable tests to be carried out.

Meta-analysis data obtained through heterogeneity testing provide opportunities for further analysis tests in effect testing. Effect testing in meta-analyses includes testing on moderator effects from causes of variation in different size effect results in each study. Moderator variable tests were conducted against the year of publication and subjects. The publication year is divided into two ranges, namely 2019-2020 and 2021-2023. Meanwhile, the subject moderator variables are divided into three, namely physics, chemistry, and biology. The results of this moderator variable test are presented in Table 3.

Table 3. Analysis of moderator variables

Moderator	k	Effect size	95% CI		Qb	p-Value
			Lower	Upper		
Year of publications					0.955	0.003
2019-2020	5	1.38	0.06	2.709		
2021-2023	16	1.01	0.540	1.542		
Subject					21.354	0.00002

Fisika	13	0.883	0.322	1.444
Kimia	5	1.649	0267	2.02
Biologi	3	1.354	0.584	2.125

Based on Table 3, it can be seen that the analysis of moderator variables in 2019-2020 obtained an effect size value of 1.38 in the large category. In 2021 to 2023, an effect size value of 1.01 was found, also in the large category. Overall, the p-value obtained was < 0.05, indicating a significant effect of the study's publication year. In the analysis of moderator variables for subjects, three categories were identified. In physics learning, the value obtained is 0.883, falling into the large category. For chemistry subjects, there is a score of 1,649 in the large category. Meanwhile, in biology subjects, a score of 1,354 was obtained, also in the large category. Overall, the p-value obtained was < 0.05, indicating a significant influence of the subjects.

The results of the study revealed the distribution of meta-analysis studies spread across physics, chemistry, and biology learning. This study was enriched by previous researchers who revealed that learning with e-modules is widely applied to biology (F. E. Putra et al., 2023). The results of the study showed that learning with e-modules achieved a great effect. E-module learning in learning also involves many models and approaches (Ferdiani, 2022; Fitria et al., 2023). The results of hypothesis testing revealed that learning with e-modules obtained significant results. These results are supported by previous research showing major effects on physics learning (Mawaddah, 2023). E-module learning as an innovation in learning by utilizing technology has been carried out in many previous studies which reveal that e-modules are easy to use in learning (Y. I. Putra et al., 2023).

The findings carried out showed that the effect of using the e-module was in the high category with a value of 1,114. These results are supported, by previous researchers related to similar studies related to the use of e-modules in biology learning at high effects (Suharyat et al., 2023). Learning with e-modules is considered better than conventional learning (Hadianto, 2020). The use of electronic teaching materials encourages students to improve the results of learning Newtonian Law of Gravity material physics (Arifuddin et al., 2023). E-module encourages student learning outcomes in improving environmental literacy skills in Chemistry learning (N. K. Dewi & Listyarini, 2022). In addition, e-modue is able to facilitate students to think critically on the physics of vibrational matter (Marlina et al., 2022). Solving problems in learning can be supported using e-modules in discussing enzyme material in biology learning (Anggraini et al., 2022).

CONCLUSION

Based on the results of a meta-analysis of 21 articles spread across physics, chemistry, and biology in the range of 2019 to 2023, it was revealed that the effect size value for learning outcomes reached 1.11, which is included in the large category. The hypothesis test confirms the significant influence of the use of e-modules in the meta-analysis process. Analysis of moderator variables by year and subject also showed a significant influence on both. From these findings, it is concluded that the use of e-modules has a significant impact on improving student learning outcomes in high school. This shows the importance of technology integration in the learning process.

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