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The Effect of Modules in Natural Science Learning on Students' Knowledge and Critical Thinking Skills: A Meta-Analysis

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Abstract: The purpose of this research is to determine the effect of modules in natural science learning on students' knowledge and critical thinking skills. This type of research is meta analysis. The subjects in this study were 20 articles that had been published in various national and international journals. The instrument used is coding. The data analysis method used is quantitative descriptive analysis which is guided by the effect size. After obtaining the effect size value, it is then classified into several groups and adjusted to the effect size category. Based on the results of data analysis, it is known that the average effect size module on knowledge is 1.36 and belongs to the very high category. While the average effect size of the module on students' critical thinking skills is 3.42 and classified in the very high category. The results in this study explain that the module has a very high influence in efforts to increase students' knowledge and critical thinking skills.

Keywords: Critical Thinking Skills; Knowledge; Meta Analysis; Modules.

Introduction

Information Technology and Science which are increasingly expanding in the 21st century are reasons for teachers to make changes in the teaching and learning process. One of the skills that must be possessed by students is critical thinking skills, with the existence of critical thinking skills students can strengthen and be competent in going through developments in the 21st century (Wagner, 2011). A lesson can be said to be successful if it is carried out actively, increases student motivation, is interactive between teachers and students, is inspiring, not boring, and challenges students to be active in learning, and the teacher provides opportunities for independence, initiative, and creativity, according to interests. the talents of students so that teachers can recognize the psychological and physical development of students (Rosyid, et al., 2019; Suwarsi, et al., 2018). However, what happens in the learning process at school is that the teacher gives limited time to understand the material so that students are only able to understand the material in limited circumstances and develop critical thinking skills (Haryadi, et al., 2017). That way students are likely to get bored interacting during the learning process.

According to Shavira, et al., (2019) the problem that often occurs in the school environment is the limited teaching materials available in this problem can refer to the 2013 curriculum, especially high school physics textbooks. According to Gunawan (2008) The saturation of students in learning subject matter, especially in science lessons, is very difficult for students to accept and interpret, this causes students to become passive and apathetic so that their learning results are less than optimal. In learning physics students only pay attention, take notes, listen and tend to be apathetic and do not ask about the material that has been explained by the teacher or express opinions so that students' critical thinking skills are not mastered and the class atmosphere becomes ineffective. The fact is that students are not interested in thinking and answering physics learning questions by taking answers directly from textbooks without analyzing them first (Darmawan, et al., 2015).

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The results or learning achievements of students must be improved, there are many ways used by teachers to improve student learning outcomes, such as developing media or teaching materials in learning. This is necessary to overcome the problem of the lack of interest in learning of students, so that teachers are advised to develop module teaching materials. The learning material that will be outlined in the module can be applied to hone students' abilities in critical thinking. Module is a teaching material that is produced as a semantic and complete teaching material, containing a set of planned learning designed so that students understand certain learning objectives. The minimum module presents learning objectives, learning material or substance and evaluation (Budi & Sunarno, 2018; Daryanto, 2013).

Modules are teaching materials that contain subject matter packaged and presented in writing with the hope that readers can receive the material independently and easily (Pertiwi, 2022; Wasisto, 2016). Meanwhile according to Direktorat Tenaga Kependidikan (2008) writing modules has the aim of explaining and simplifying in presenting material so that it is not too rigid and verbal, a solution for limited time for readers to understand the material, use it appropriately and varied, and can make students measure or evaluate their own learning outcomes (Pertiwi, 2022).

Module development on students' knowledge and critical thinking skills has been widely carried out by practitioners and academies. Various articles and research that seeks to explore modules have shown how special this teaching material is. Based on that, the researcher is interested in uncovering the magnitude of the module's contribution to students' knowledge and critical thinking skills by analyzing various research reviews that have been conducted.

Learning modules as printed teaching materials have been widely used by teachers both in natural science learning and in various module forms. However, it is better if you know exclusively about the influence of the teaching materials in the module, so you will do an analysis from several published scientific research documents. The analysis used is called meta analysis. Meta analysis is research by utilizing studies existing and used by researchers to be tested qualitatively and systematically to obtain reliable and precise conclusions (Mayasari, et al., 2022; Retnawati, et al., 2018). The advantage of meta-analysis is that it can determine in detail the effect of the module on each variable and level of education. Therefore, this study aims to determine the effect of the module on students' knowledge and critical thinking skills.

Method

This research is a meta-analytic research method. Meta-analysis is a study of summarizing, reviewing, and analyzing data obtained from published scientific journals. Meta-analysis has a research method that examines scientific journals in national and international journals that have been accredited by SINTA. The subjects of this study were 20 national and international journal articles. The criteria for the articles used are: the scientific articles used examine the effect of the module on students' knowledge and critical thinking skills. Second, these articles are published by national and international journals that have ISSN. The stages of this research are shown in the flowchart presented in Figure 1.

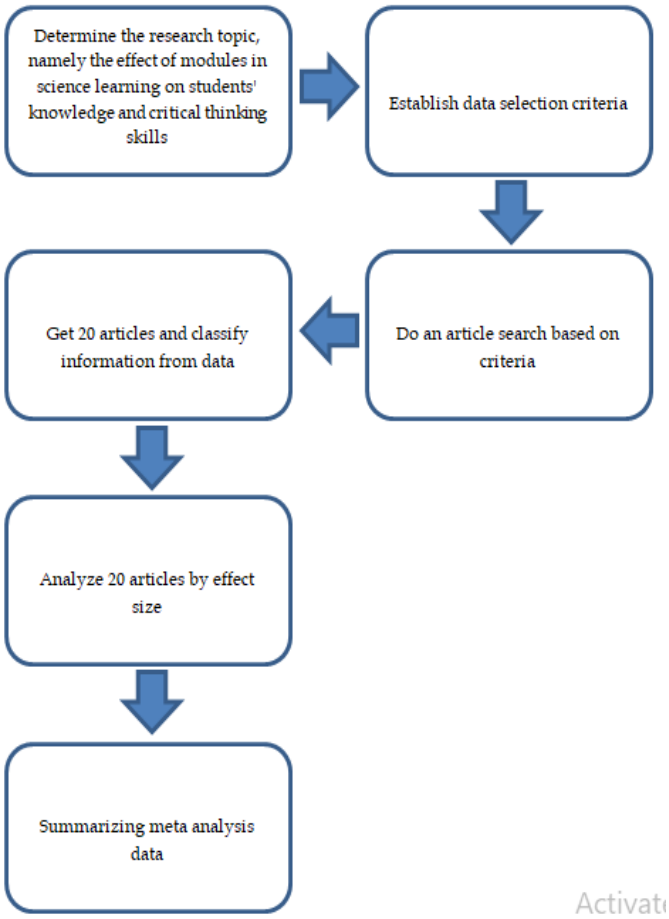

Figure 1. Meta Analysis Research Flow

In analyzing the data, there are steps that must be carried out, the first is to determine the variables and types of research and to affix data to the group column, the second to determine the mean and standard deviation of the group data that has been affixed, and the third, namely the effect size value is calculated using statistical parameters in Table 1.

Table 1. How to Determine the Magnitude of the Effect Size

Statistics	Formula
Average in one group	$ES = \frac{\bar{X}_{post} - \bar{X}_{pre}}{SD_{pre}}$
Average in each group (two groups posttest only)	$ES = \frac{\bar{X}_E - \bar{X}_C}{SD_c}$
Average in each group (two groups pre-post tests)	$ES = \frac{(\bar{X}_{post} - \bar{X}_{pre})e - (\bar{X}_{post} - \bar{X}_{pre})c}{SD_{pre\,C} + SD_{pre\,E} + SD_{post\,C}}$
Chi Square	$ES = \frac{2r}{\sqrt{1-r^2}}\,; r = \sqrt{\frac{x^2}{n}}$
t count	$ES = t\sqrt{\frac{1}{n_E} + \frac{1}{n_C}}$
p value	CMA (Comprehensive Meta Analysis Software)

After calculating the effect size value according to the right formula, then categorizing the effect size according to the criteria Cohen (1981) as in Table 2.

Table 2. Criteria Effect Size (ES)

ES	Category
0.00≤ES<0.20	Ignore
0.20≤ ES<0.50	Low
0.50≤ ES<0.80	Currently
0.80≤ ES<1.30	Tall
1.30≤	Very high

Result and Discussion

This research is used to determine influencemodule on students' knowledge and critical thinking skills. To calculate the effect size of the article, data obtained from the appropriate journal is used. The sources that researchers use in collecting data include Google Scholar, science education journals and several other journals. The number of articles used in this research is 20 articles selected according to predetermined criteria. First, research on modules. Second, the module is applied in natural science learning. Third, the module has an influence on students' knowledge and critical thinking skills. The results of calculating the effect size of the 20 articles were analyzed by classifying the articles into several groups. Table 3 shows the results of the effect size analysis in general about the effect of the module on students' knowledge and critical thinking skills.

Table 3. Analysis of the Effect Size in General

Article Code	level	ES	Category
A1	Junior High School	1.94	Very high
A2	Junior High School	0.68	Currently
A3	Senior High School	2.12	Very high
A4	Junior High School	1.31	Very high
A5	Senior High School	2.57	Very high
A6	Senior High School	10.68	Very high
A7	Senior High School	0.69	Currently
A8	Senior High School	0.53	Currently
A9	Senior High School	7.7	Very high
A10	Senior High School	4.14	Very high
A11	Senior High School	0.44	Low
A12	Senior High School	1.33	Very high
A13	Junior High School	2.41	Very high
A14	Senior High School	2.10	Very high
A15	Senior High School	0.54	Currently
A16	Junior High School	2.39	Very high
A17	Senior High School	2.40	Very high
A18	Senior High School	2.85	Very high
A19	Senior High School	0.49	Low
A20	Senior High School	0.54	Currently

Table 3 shows the effect size of the module on knowledge of 1.36 and belongs to the very high category. Meanwhile, the effect size of the module on critical thinking skills is 3.42 and belongs to the very high category. Through the results of this analysis it is known that the module has a very high effect on the process of increasing students' knowledge and critical thinking skills. In line with research Ardiansyah, et al., (2019) who said the improvement of critical thinking skills could be through the use of contextual modules based on multiple representations. This is due to the advantages of the module. In the module, it is presented in an interesting way regarding the phenomena of everyday life problems. The module also provides evaluation questions related to physics events in everyday life. This module encourages students to connect their knowledge with the real world, makes students active in learning the concepts in the module and directs students to get something concrete in everyday life. The learning process becomes fun so that the material is easier for students to understand.

According to Shavira, et al., (2019) The advantages of using computer media-assisted modules and phet simulation applications according to contextual learning syntax in a class are facilitating students' understanding of the material and making learning more meaningful. This has an effect on improving students' critical thinking skills. Through research Ulandari, et al., (2018) it is known that the module through a scientific approach has an influence on learning outcomes through controlling critical thinking skills. Table 4 shows the effect size when classified by education level.

Table 4. Effect Size Analysis Based on Education Level

Educational level	Code	ES	Mean	Category
Junior High School	A1	1.94		
	A2	0.68		
	A4	1.31	1.75	Very high
	A13	2.41		
	A16	2.39		
Senior High School	A3	2.12	2.61	Very high
	A5	2.57		
	A6	10.68		
	A7	0.69		
	A8	0.53		
	A9	7.7		
	A10	4.14		
	A11	0.44		
	A12	1.33		
	A14	2.10		
	A15	0.54		
	A17	2.40		
	A18	2.85		
	A19	0.49		
	A20	0.54		

Table 4 shows the effect size of the module on knowledge and critical thinking skills at the junior high school level of 1.75 and belongs to the very high category. Student learning outcomes can be improved through the Middle School natural science module which is applied using the Exploration of the Surrounding Nature (JAS) approach in the material on the movement of the earth and the moon which is integrated with Javanese culture (Pratama, et al., 2015). Meanwhile, at the senior high school education level, the effect size module on knowledge and critical thinking skills is 2.61 and belongs to the very high category. Based on the analysis of the data obtained, this is consistent with Novita, et al., (2018) which shows differences High school students who use module teaching materials with a scientific approach will see the difference with students who do not use a scientific approach. Table 5 shows the effect size value of the module on students' knowledge and critical thinking skills by subject.

Table 5 shows that in biology subject the effect size module on knowledge and critical thinking skills is 1.31 and belongs to the very high category. There is a difference between the control class and the experiment in learning outcomes, and there is a positive correlation between motivation and learning through the use of learning modules based on the Koran and hadith in reproductive system material (Agusti, et al., 2020). In line with research results Budi & Sunarno (2018) who concludes the natural science module with the SETS approach. The ecosystem theme is effective in the process of improving students' critical thinking skills.

Table 5. Effect Size Analysis Based on Subjects

Subjects	Code	ES	Mean	Category
Biology	A1	1.94		
	A2	0.68	1.31	Very high
	A4	1.31		
Physics	A3	2.12	2.58	Very high
	A5	2.57		
	A6	10.68		
	A7	0.69		
	A8	0.53		
	A9	7.7		
	A10	4.14		
	A11	0.44		
	A12	1.33		
	A13	2.41		
	A14	2.10		
	A15	0.54		
	A16	2.39		
	A17	2.40		
	A18	2.85		
	A19	0.49		
	A20	0.54		

While in physics it can be seen that the effect size of the module on knowledge and critical thinking skills is 2.58 and is classified in the very high category. Critical thinking skills can be improved through physics modules with a scientific approach in static fluid material (Puspitasari, et al., 2015). From research results Marnah (2022) It is known that the physics module he developed, especially on mechanical wave material in high school students' classes, was very effectively applied in an effort to improve critical thinking skills in physics lessons, especially in their learning outcomes. Table 6 shows the effect size value of the module on students' knowledge and critical thinking skills based on the learning model.

Table 6 shows that the effect size of the module on students' knowledge and critical thinking skills through concept mapping, investigation and problem based learning models is 1.33, 2.10, and 1.34 with very high categories. The physics module with the PBL model is effective in the process of increasing students' cognitive, affective, and psychomotor learning outcomes (Jauhariyah, et al., 2013). Research results Agustina, et al., (2022) explained that the physics module of the problem based learning model had an effect on students' critical thinking skills. Learning modules that use concept maps or mapping have an effect on student learning outcomes compared to learning that does not use concept maps (Hardanti, et al., 2016).

Table 6. Effect Size Analysis Based on the Learning Model

Learning model	Code	ES	Mean	Category
Inquiry	A15	0.54	0.54	Currently
Concept Mapping	A12	1.33	1.33	Very high
Investigation	A14	2.10	2.10	Very high
Problem	A1	1.94	1.34	Very high
Based	A3	2.12		
Learning	A8	0.53		
	A16	2.39		
	A19	0.49		
	A20	0.54		
Discovery Learning	A11	0.44	0.44	Low

While the effect size of the module on students' knowledge and critical thinking skills through the inquiry and discovery learning models is 0.54 and 0.44 in the moderate category. the effect of the physics module with the inquiry model on students' cognitive learning outcomes (Gumay, et al., 2020). The module implemented with the discovery learning model influences learning outcomes in three aspects namely knowledge, attitudes and skills (Fernanda, et al., 2015). Through some relevant research it is explained that the module has an effect on improving students' critical thinking skills. Besides that, it is also seen that the module can be combined with various forms of learning such as contextual, Problem Based Learning, and others which cause this teaching material to have great potential in improving students' critical thinking skills.

Conclusion

Through the results of data analysis, it can be concluded that the effect size of the module on students' knowledge and critical thinking skills shows various results ranging from low to very high categories. From the results of the researchers' observations, in searching for articles in this research, there were many module development articles. However, there are still few articles regarding the effect of module implementation on students' knowledge and critical thinking skills. For this reason, the researcher hopes that other researchers can use this as a source of inspiration for future research.

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Conflicts of Interest
The author's interest in publishing this article is for research output needs in the form of publication in scientific journals as proof of the required performance. There is no conflict of interest in carrying out and publishing this study.

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