



Improving the Critical Thinking Ability of Vocational High School Students through Digital Teaching Material

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ABSTRAK

Variasi yang terbatas dalam metode pengajaran matematika dapat berdampak negatif pada pencapaian siswa dalam mata pelajaran tersebut. Oleh karena itu, tujuan penelitian ini adalah untuk mengevaluasi dampak penggunaan e-book sebagai media pembelajaran terhadap kemampuan berpikir kritis siswa. Penelitian ini menerapkan pendekatan eksperimen dengan melibatkan kelompok kontrol dan kelompok eksperimen. Penelitian ini melibatkan 70 siswa SMK yang dibagi menjadi dua kelompok. Metode pengumpulan data menggunakan tes. Instrumen pengumpulan data menggunakan soal tes. Teknik analisis data menggunakan statistik inferensial. Temuan penelitian menunjukkan bahwa penggunaan e-book atau materi ajar digital secara signifikan berkontribusi pada peningkatan kemampuan berpikir kritis siswa. Kesimpulan yang dapat ditarik adalah bahwa e-book terbukti efektif dalam memengaruhi dan meningkatkan kemampuan berpikir kritis siswa. Hasil penelitian ini menggarisbawahi potensi besar dari media pembelajaran digital, seperti e-book, dalam meningkatkan kemampuan berpikir kritis siswa di lingkungan sekolah menengah kejuruan. Oleh sebab itu implementasi media interaktif dalam format e-book dirasa perlu untuk luas di sekolah-sekolah kejuruan dengan harapan, mampu meningkatkan keterampilan berpikir kritis siswa sebagai bekal mereka menghadapi tantangan – tantangan di pekerjaan maupun kegiatan wirausaha.

ABSTRACT

Limited variety in mathematics teaching methods can harm student achievement in the subject. Therefore, this research aims to evaluate the impact of using e-books as a learning medium on students' critical thinking abilities. This research applies an experimental approach involving control and experimental groups. This research involved 70 vocational school students who were divided into two groups. The data collection method uses tests. The data collection instrument uses test questions. Data analysis techniques use inferential statistics. Research findings show that using e-books or digital teaching materials significantly improves students' critical thinking abilities. The conclusion that can be drawn is that e-books have proven effective in influencing and improving students' critical thinking abilities. The results of this research underline the great potential of digital learning media, such as e-books, in improving students' critical thinking skills in vocational high school environments. Therefore, it is deemed necessary to widely implement interactive media in e-book format in vocational schools to improve students' critical thinking skills to equip them to face challenges in work and entrepreneurial activities.

1. INTRODUCTION

Teaching materials are a set of learning tools or tools that contain learning materials, methods, limitations and ways of evaluating that are designed systematically and attractively in order to achieve the expected goals, namely achieving competencies or sub-competencies with all their complexity (Dafit & Mustika, 2021; Wahyuni et al., 2022). So that teaching materials have an important role in learning. Teaching materials can be grouped into four categories, namely: printed teaching materials, audio teaching materials, audio visual teaching materials and interactive teaching materials (Misrawati & Suryana, 2021; Muharni et al., 2021). The use of appropriate teaching materials and ICT resources can assist in conveying the content of the lesson, besides that it can also attract interest and make the learning process not boring (A. I. Sari et al., 2020; Sariyatun et al., 2021). Along with that, it's important for us to know together that, the teaching and learning process as an illustration of the interaction between students and educators certainly has a purpose (Haryati et al., 2021; Kurniawan et al., 2018). Therefore, the teacher or educator should play more of a role as a facilitator and motivator of the learning process among students, shape and provide

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convenience so that students get a learning experience that suits their needs and abilities so that there is an active interaction (Junaidi, 2019; Wibawa et al., 2019).

Currently, a curriculum system is being implemented that will apply as a whole, namely the independent curriculum. The Independent Curriculum (*Kurikulum Merdeka*) seeks to encourage learning that is in accordance with students' interests, learning styles and student abilities, as well as providing a wider space for character development and basic competencies that are in line with the concept of independent learning. The Merdeka Curriculum has several characteristics including project-based learning for the development of soft skills and students' character which encourages faith; piety; and noble character; mutual cooperation; global diversity; independence; critical thinking and creativity (Rosmana et al., 2022; Widiyono & Millati, 2021). One of the goals of the Merdeka curriculum which is part of the Pancasila student profile that critical thinking is different from ordinary thinking or routine thinking, critical thinking is an intellectual thinking process which deliberately assesses the quality of thinking reflectively, independently and rationally (Anisa, 2017; Nafi'ah et al., 2019). Critical thinking is the ability to understand a problem by selecting relevant information which can ultimately draw valid conclusions (Kurnianto & Haryani, 2019; Tusriyanto et al., 2019). The ability to think critically or critically think of students in learning mathematics needs to be developed so that students have the ability to think and solve problems in real life and in the industrial world, this is in accordance with the objectives in the Merdeka curriculum for the SMK level which includes increasing critical thinking skills (Claris & Riley, 2012; Nawawi et al., 2020; Wilkin, 2017).

The low ability of students' critical thinking can actually be overcome in various ways, in the field of education, for example, educators need to encourage and pay more attention to learning, so that students' critical thinking skills can be instilled from an early age. Although the effect of education on improving students' critical thinking skills tends to be positive, these results are not in line with the increase in learning outcomes which are still too high (Anderson & Rivera-Vargas, 2020; Naveed & Ahmad, 2019). One of the factors that causes this is the implementation of learning which is still theoretical in nature, and irrelevant to social problems even though this potential is very adequate if used as learning material (De Witte et al., 2015). The importance of critical thinking skills can be facilitated in educational activities, one of which is through learning mathematics, which in the output and learning objectives are expected to be able to equip students with critical thinking skills and mathematical skills (Hafeez, 2021; Zwart et al., 2017). It's just that, keep in mind that the success and achievement of learning goals in mathematics cannot be separated from various factors, including the use of technology in the delivery of learning material in the form of learning media (Raja & Nagasubramani, 2018; Rasiman et al., 2020). Learning media packaged in e-book or digital book formats is an innovation in the use of technology that can be applied in almost all lines of education (Lawson-Body et al., 2020; Perdana et al., 2021).

Besides that, the lack of variety in the use of digital teaching materials, the assessment process that has been adopted so far has also caused the focus of achievement only on the cognitive aspect, so that teachers assume that other abilities such as students' critical thinking abilities tend to be lacking or low. Furthermore, based on the results of interviews with mathematics teachers in vocational schools, it is informed that so far it has not been identified how the conditions and abilities of students' critical thinking are described through the learning process, where during the learning process the teacher has never taken measurements of students' critical thinking abilities before, because during In this case the teacher only focuses on providing material and assignments as a form of student learning outcomes.

The development of science and technology began to penetrate the world of education. This allows the development of mathematics learning in vocational schools to utilize ICT. One of them can be through e-books as learning media, this learning media will be a learning tool or tool that is more effective in delivering material and efficient in the use of time and energy (Lasfika et al., 2022; Nisak & Yulkifli, 2021). Several reasons for using electronic media can increase the effectiveness of the learning process, namely: 1) it allows direct interaction between students and subject matter, (2) the learning process can take place individually according to the learning abilities of students, (3) being able to display audio-visual elements for increase interest in learning, (4) able to create a continuous learning process.

The results of various studies have found that the use of e-books in the learning process is more effective (Nandiyanto et al., 2020; Sofyan et al., 2019). Overall e-books and digital books have basically been implemented for a long time, the use of this technology empirically is able to show an increase in student academic and non-academic achievements (Velan et al., 2015), mastery of subject concepts both exact and social (Hadiyanti et al., 2021; Susanti et al., 2020), able to influence the affective aspects of students, as well as improve students' 21st century skills (Hamid et al., 2020; Pertiwi et al., 2018). Although this research highlights the level of effectiveness of e-books in increasing critical thinking skills, there is still a need to dig deeper into the specific aspects of e-books that contribute most to this increase, such as interactive elements, special content, or engaging learning designs. In addition, most of the research may focus on test

results or academic assessments, but it is also necessary to consider how the development of critical thinking skills through e-books can be integrated into real-life situations or professional contexts that are relevant to students in vocational high schools.

Based on the description above, the integration of ICT in learning mathematics in Vocational High Schools is a must. It is necessary to reform learning from conventional to constructivist learning by making the widest possible use of technology to facilitate student learning as well as make it easier for students to learn. Effective integration of technology in learning allows teachers and students to access concepts more easily, and can represent abstract concepts, so this study aims to identify the effect of using e-books on increasing critical thinking skills of SMK students in learning mathematics.

2. METHODS

The research conducted is included in the quantitative research with the type of experiment (Cobb et al., 2003), it's just that for this type of research it adopts a quasi-experimental design with a nonequivalent control group design (Sugiyono, 2018). The total sample in this research used 70 vocational high school students, which were divided into a control class of 35 students and an experimental class of 35 who were randomly selected (Handayani et al., 2020). In short, the control class is a class that during the learning process does not use flipbooks in learning, while the experimental class is a class that during the learning process uses flipbooks as a learning media. Meanwhile, the data collection technique was carried out by giving tests of students' critical thinking skills for mathematics subjects followed by a test instrument with a grid of items for the preparation of the test showed in Table 1.

Table 1. Mathematical Critical Thinking Instruments Grid

General Indicators	Question Indicator	Cognitive Level
Interpretation	Students can arrange matrix equations that are known to be problems in real life	C4
	Students can understand the value of row and column elements	C4
	Students can arrange matrix forms from inverse concepts in everyday life	C4
	Students can evaluate the value of x if it is known from three matrices of order 2x2 and the determinant relationship of the three matrices is known	C5
	Students can analyze everyday problems using the inverse matrix concept	C5
Analysis	Students can analyze the two inverse matrices if 4 matrices of order 2x2 are known	C5
	Students can analyze the cofactor values of an order matrix	C5
	Students can analyze and calculate the determinants of matrices from the elements of addition and subtraction matrices	C5
	Students can analyze and calculate the matrix inverse of the two elements of addition and matrix multiplication presented	C5
	Students can determine the value of the row and column elements of the matrix that has been presented	C4
Evaluation	Students can determine the value of the determinant matrix of the first order	C4
	Students can determine the value of the inverse matrix of order 2x2	C4
	Students can determine the X matrix if the elements of the inverse matrix are known	C4
Inference	Students can find the elements of a 2x2 matrix if the determinant value is known	C5
	Students can calculate the inverse matrix of order 3x3 from the matrix that has been presented	C4

Adopt from (Changwong et al., 2018; Hobri et al., 2018; Rahmati et al., 2018)

Before the questions are distributed to students, the instrument must first go through the stages of validity and reliability testing. In the validity test, this instrument was tested on 24 students (N = 24) with the help of the SPSS 25 program. The results of the validity test showed that out of 20 items, all were declared valid. Furthermore, for reliability testing, namely the results of the instrument item reliability test using the Cronbach's Alpha test. Based on the table of reliability test results, the test results stated a score of 0.489. While the rtable for 24 students is 0.404 (N = 24), then the instrument used in this study is valid if

$r_{count} > r_{table}$, so $0.489 > 0.404$. This shows that the critical thinking ability items distributed to students are declared reliable as a data collection tool.

Then, the scores obtained by each group will be analyzed. In this research, the data analysis technique used is an inferential statistical analysis technique using the t test. This t test is intended to test data from each group with data sources, namely the results of the pretest and posttest, the purpose of this t test is to see whether there is a significant difference in the results of the posttest scores related to students' critical thinking abilities (Maisarah, 2019).

3. RESULT AND DISCUSSION

Results

As a form of prerequisite test, the homogeneity test aims to determine whether the variance of the research subjects comes from a homogeneous sample or not. The basis for making a decision for this homogeneity test is if the Significance or Sig. < 0.05 , then it is said that the variance is not homogeneous, otherwise if Sig. > 0.05 it is said that the variance of the population group in the research is homogeneous. The results of the homogeneity test using the SPSS 25 application at each stage, namely the pre test stage and the post test stage showed in Table 2.

Table 2. Homogeneity Test Results

		Levene Statistic	df1	df2	Sig.
Critical Thinking (Pre-test)	Based on Mean	0,163	1	68	0,688
Critical Thinking (Post-test)	Based on Mean	3,036	1	68	0,086

Based on the table above, it is known that the significance value (Sig) of the variable resulting from the ability to think critically in the Experiment class and Control Class students is 0.086. Because the significance value or Sig. $0.086 > 0.05$. So it can be concluded that the variance of critical thinking skills obtained from the post-test scores in the experimental class and control class is homogeneous.

This study uses data normality testing which refers to the Shapiro Wilk technique with the help of SPSS 25. The use of the Shapiro Wilk technique is based on the use of samples in each class of no more than 150 students (< 150), where the total sample in this test consists of 35 students in the experimental class and 35 students in the control class.

The decision making for the results of the normality test is based on the results that if the data is normally distributed, that is, it has a significance level > 0.05 , otherwise if the significance level is < 0.05 , then the data is not normally distributed. The results of the data normality test at each stage, both from the pre-test and post-test showed in Table 3.

Table 3. Normality Test Results

Class	Kolmogorov-Smirnova			Shapiro-Wilk			
	Statistic	df	Sig.	Statistic	df	Sig.	
Critical Thinking (Pre-test)	Experiment Class	0,161	35	0,022	0,946	35	0,084
	Control Class	0,116	35	0,200*	0,958	35	0,203
Critical Thinking (Pre-test)	Experiment Class	0,170	35	0,012	0,939	35	0,051
	Control Class	0,167	35	0,014	0,942	35	0,065

It is known from the output that the value of Sig. for the experimental class of 0.084 and the value of Sig. for the control class is 0.203 where the two Sig. > 0.05 , based on the decision of the Shapiro Wilk Normality Test, it can be concluded that the critical thinking ability data obtained from the implementation of the pre-test for students in the experimental class and control class is normally distributed. Meanwhile, next is the normality test data from the implementation of the post test activities. It is known from the output that the value of Sig. for the experimental class of 0.051 and the value of Sig. for the control class is 0.065 where both Sig. > 0.05 , the decision of the Shapiro Wilk Normality Test can be concluded that the critical thinking ability data obtained from the implementation of the post test for students in the experimental class and control class is normally distributed. Based on the prerequisite tests carried out, it was identified that the pre-test and post-test results data had fulfilled the requirements for hypothesis

testing to be carried out in order to determine the level of effectiveness of the digital teaching material products being developed.

After going through the prerequisite tests, namely the homogeneity test and the normality test, which concludes that the data is normally distributed and the variance used by the population is homogeneous, the next test is hypothesis testing with the t-test technique, namely the Independent Sample T-Test. This section will describe the statistical results of the Independent Sample T Test using the SPSS 25 application. Shown in [Table 4](#).

Table 4. Results Description Statistics

Class			N	Mean	Std. Deviation	Std. Error Mean
Critical Thinking (Pre-test)	Experiment Class		35	61,86	8,409	1,421
	Control Class		35	47,14	9,258	1,565
Critical Thinking (Post-test)	Experiment Class		35	92,14	7,405	1,252
	Control Class		35	45,43	9,265	1,566

Based on the output of Group Statistics, it is known that the amount of data on learning outcomes for the experimental class is 35 students, and for the control class is 35 students, the average value of critical thinking skills for the experimental class is 61.86 while for the control class it is 47.14. Based on the output of Group Statistics, it is known that the total data on learning outcomes for the experimental class is 35 students, and for the control class is 35 students, the average value for critical thinking ability is 92.14 while for the control class it is 45.43. It was identified that there was a difference in the average critical thinking ability of students in the experimental class and the control class. The results of the test interpretation of the t-test showed in [Table 5](#).

Table 5. Independent T-Test Statistical Results

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper	
Critical Thinking (Pre-test)	Equal variances assumed	0.180	0.673	6.960	68	0.155	14.714	2.114	10.496	18.933
Critical Thinking (Post-test)	Equal variances assumed	0.732	0.395	23.301	68	0.029	46.714	2.005	42.714	50.715

Based on the output of statistical calculation results, it is known that in the equal variances assumed section, the value of Sig. (2-tailed) of $0.155 > 0.005$, then as the basis for making a decision that H_0 is accepted and H_1 is rejected. So it can be concluded that there is no significant (real) difference between the average critical thinking ability of students in the experimental class and the control class at the pre-test stage or before the use of digital teaching material products that are developed, in other words, the initial ability of students is good in class experimental and control class are the same. Meanwhile, it can be seen from the results of the post-test, statistical calculations were produced in the equal variances assumed section of Sig. (2-tailed) of $0.029 < 0.005$, then as the basis for making a decision that H_0 is rejected and H_1 is accepted. So it can be concluded that there is a significant (significant) difference between the average critical thinking ability of students in the experimental class and the control class, where the experimental class is students who use digital teaching materials when carrying out the learning process and the control class is students who have learning process using media or other teaching materials.

Discussion

Optimizing the use of ICT, and integrating ICT into the learning process needs to be followed up by all academics and education practitioners. Innovative learning is one of the strategies that emphasize the

delivery of material in two directions, and the use of learning resources that are in accordance with the needs and material presented, thus learning objectives can be achieved, both cognitive, affective and psychomotor goals (Aeni & Yusupa, 2018; Wahyu, Purwadi et al., 2021). This is of course the best compared to field findings, it was found that during the research process teachers still tended to use printed modules and material books provided by the school. One of the efforts made by the teacher is to combine them through the use of videos and other learning resources from the internet, with the hope that information from websites and videos can make it easier for students to understand the material (Lasfika et al., 2022; Dewi et al., 2019).

Referring to the results of testing the level of effectiveness of teaching material products, it appears that the digital teaching materials that have been developed are proven to be quite effective in improving the critical thinking skills of students at SMK in Surakarta. It can be seen from the results of statistical testing that the significance level of Sig. (2-tailed) $0.029 < 0.05$ which means that there is a difference in the average value of learning outcomes between students in the experimental class and students in the control class. These results also show the results of hypothesis testing, namely H_0 is rejected and H_1 is accepted. So it can be concluded that there is a significant (significant) difference between the average critical thinking ability of students in the experimental class and the control class, where the experimental class is students who use digital teaching materials when carrying out the learning process and the control class is students who have learning process using media or other teaching materials. The results of increasing critical thinking skills cannot be separated from the concepts and benefits contained in digital media in the e-module format when used during the learning process (Kimianti & Prasetyo, 2019; Nithyanantham et al., 2019; Ran & Jinglu, 2020). As we all know, media is a tool that teachers can use to process, capture, and convey information from one person to another who receives it, in this case students, with the hope that messages in the form of material can be easily understood by students (Latifah et al., 2020; Widya et al., 2021).

In addition, from the results of this research it is also proven that the use of appropriate teaching materials in conveying appropriate and varied information and educational materials can overcome the passive attitude of students (Ambarsari et al., 2021; Maharani Zan & Mardian, 2022). The use of learning media in digital formats has succeeded in having a positive impact on increasing students' mathematical literacy abilities (Amalia et al., 2021; Saputra & Salim, 2020). However, the difference with this research that has been done is the type of learning outcome variable that is measured, where in this research the focus is on measuring critical thinking learning variables. The use of electronic modules for learning can actually improve learning outcomes, this indicates that the use of digital learning media in the e-module format can also have a positive impact on improving student learning outcomes (Maharani Zan & Mardian, 2022; Sari & Manuaba, 2021). From this research it appears that the use of digital learning media in the e-module format can have a positive impact on improving student learning outcomes. Along with the development of technology, teaching materials have undergone various developments, so that teaching materials are currently not only known as printed format materials, but also digital formats. This development certainly has a positive impact on the quality of the quality of the process and learning outcomes.

Digital teaching materials that can be accessed through digital devices are proven according to several studies to be able to improve critical thinking skills. The use of digital teaching materials in the form of electronic modules it contributes positively to improving critical thinking skills (Latifah et al., 2020; Riyanto et al., 2020). In addition, one of the innovations in learning activities can be carried out through the development of ICT-based teaching materials, these teaching materials can be adopted by various subjects such as mathematics, through the use of ICT-based teaching materials, students are more facilitated in understanding concepts and being practical in working on questions - high-level math questions (HOTS) (Muharni et al., 2021; Tambunan & Sundari, 2020). Therefore, currently the role of ICT is expected to be optimized by educators such as teachers so that learning outcomes and competencies that are important in the 21st century can be achieved immediately (Wijaya, 2020; Yilmaz, 2021).

Some research also shows that the use of ICT both in the form of teaching materials, learning media, learning multimedia also contributes to student learning outcomes (Aufa et al., 2021; Roemintoyo & Budiarto, 2021). Besides being important for teachers to make it easy for students to achieve learning goals, keep in mind that teachers must also be able to facilitate students to master the various abilities needed in the 21st century (Julaihi & Hamdan, 2020; Nesri & Kristanto, 2020). In the Merdeka curriculum which is currently enforced and implemented in several schools in Indonesia, it is stated that one of the abilities that must be given to students is the ability to think critically (Rosmana et al., 2022; Selviani, 2019). These competencies or abilities are certainly in line with what is needed by students in the 21st century so that they can compete in the era of globalization (Barnett & Botes, 2022; Pamungkas et al., 2020). Besides that, as a developing country, it should be before optimizing a digital-based economy, it must start with the use of digital devices and optimizing digital devices in the Education sector considering that currently there are

still very few ICT-based digital devices that are applied to the Education sector, specifically the learning process (Gellerstedt et al., 2018; Lim et al., 2020). Even though almost all students and teachers are familiar with the presence of technology, such as smartphones. Of course this can be a good start to providing and presenting ICT-based teaching material innovations in e-module format into the learning process that uses its learning foundation, namely the Merdeka curriculum (Aufa et al., 2021; Ningtyas & Jati, 2018; Yaniawati et al., 2021).

Through this research it can be seen that the product developed, namely, digital teaching materials has advantages including: easy to use, technology-based operation, attractive design and navigation during its use for the learning process, thus making the material presented through this format more interesting, available practice questions, there is an explanation of the material in audio-visual format (Eladl & Musawi, 2020; Ivanović et al., 2018). What is unique and new about this research is that it is clear the role of digital learning media in improving critical thinking skills. This research provides strong evidence that consistent and directed use of digital learning media can provide concrete benefits in developing students' critical thinking skills. These findings have the potential to provide valuable guidance for the development of curriculum and learning strategies that are more effective in the digital era, as well as strengthen the relevance of technology in the educational process in vocational high schools (Scheiter, 2021). Therefore, in order to achieve and provide competence in the form of students' critical thinking skills, teachers have a vital role to facilitate student learning. The use of ICT-based teaching materials is felt to play an important role so that the process of facilitating students by teachers can run optimally (Roemintoyo et al., 2022; Yacob, 2020). Given the ability to think critically is one of the important competencies to be mastered by students in the 21st century (Abdulah et al., 2021; Voogt & Roblin, 2012).

However, this research still has limitations, namely the application of digital media in e-book format is limited to one material, this is because if all the material in 1 semester of teaching materials is converted to digital format, it will result in a large size of teaching materials. Besides that, the reference source in the form of audio-visual media contained in teaching materials also still refers to YouTube, not from the explanations of each teacher so that maybe for some students the speakers tend to be foreign. Another limitation is that the variables measured are still limited to the ability to think critically.

4. CONCLUSION

The application of technology has been proven to be able to facilitate student learning, as seen from the increased critical thinking skills of each student through the use of digital learning media in e-book format. This study succeeded in answering the problem formulation and decided to test the hypothesis which shows that digital media in e-book format has succeeded in having a positive impact on increasing student achievement, especially critical thinking skills. The average post-test results that show differences are indicators of increased critical thinking skills. Improving critical thinking skills in vocational students is a top priority because these skills help them face complex challenges in the world of work and everyday life. By using digital learning media in e-book format, the findings of this study make a significant contribution in creating a learning environment that is more interactive, inclusive, and relevant to current technological developments.

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