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IMPROVING THE QUALITY OF EDUCATION THROUGH EFFECTIVENESS OF E-MODULE BASED ON ANDROID FOR IMPROVING THE CRITICAL THINKING SKILLS OF STUDENTS IN PANDEMIC ERA

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ABSTRACT

This research aimed to improve the quality of education through effectiveness of e-module based on android for improving the critical thinking skills of students in pandemic era. There were 414 students as the subject of this research at Public High School 76, class X, XI, XII, Jakarta-Indonesia, from August 2020 to December 2020. This research used the purposive sampling technique with 197 students (class X) as the experimental class using e-module based on android and 217 students (108 students in class XI and 109 students in class XII) as control class using a simple printed module in this school. This method used a quasi-experimental design with a pretest-posttest control group. The instrument used in this method was the learning implementation plan of heat and temperature material with the test in the form of descriptions based on indicators of critical thinking skills (1. elementary clarification, 2. basic support, 3. advanced clarification, 4. strategy and tactics). The result of this research was that the use of e-module based on android application on the topic of heat and temperature was more effective in increasing critical thinking skills compared to using a simple print module. Evidenced by the magnitude of the influence of e-module based on android application in solving critical thinking ability test questions at class X, XI, XII Public Senior High School 76 Jakarta was 0.67, in the interpretation table Cohen's value was 75.1% classified as moderate. The conclusion showed that improving the quality of education through applying this e-module can be used for the teaching and learning process on the topic of heat and temperature so that it can improve students' critical thinking skills.

Keywords: **E-Module Based on Android, Critical Thinking Skills, Quality of Education**

INTRODUCTION

The current quality of education is focused on student achievement and brings reforms in curricula and education standards. Another aspect of education quality is related to the relevance of what is taught and learned. The system must suit individual needs and requirements. Education is a formal institution, in which there is a process of transmitting values in society, skills and knowledge from one person, group, and from one community to another (Bazhenov et al., 2015). Therefore, the participation of public institutions in determining criteria, monitoring the quality of education, and analyzing the results is important. Assessment of the quality of education, in this case, is an instrument to obtain objective and valid information about the conditions and results of the educational process, to determine the effectiveness of e-module based on android on heat and temperature topics for improving the critical thinking skills of the student in a pandemic era. Second, there is still a lack of understanding between educators or teachers about teaching methods that can improve student's critical thinking skills (Anderson & Krathwohl, 2001). The challenge made by the Indonesia government is how Indonesian education prepares people who can build and participate well in the 21st century by involving learning in 4 abilities of the 21st century skills, namely, critical thinking, collaboration, creative and innovative ideas and communication as well. In the 2013 Curriculum, one of the competencies that students must master in learning science, especially physics, in this case is critical thinking skills (Kemdikbud, 2018).

Based on the results of direct observations at Public Senior High School 76 Jakarta-Indonesia during the physics learning process in class, it seems that the teacher has succeeded in using the media when delivering the material in class and when online learning class. However, there are some obstacles when the teacher delivers the material, namely (1) students still doing recall thinking, doing basic thinking, only 50% doing critical thinking and creative thinking. (2) the learning sometimes still teacher centered, so that the teacher dominates the learning process, (3) sometimes the material is still conventional because the material is only a conversion from the previous print (4) only delivers material limited to books package or handle. When students are given questions, their answer according to the contents of the textbook. When asked why they answered this way, students could not explain the reasons for the answers they produced. Also, learning in the classroom still does not reflect the ability to think critically, while physics lessons are needed critical thinking skills that can help develop students' thinking. This is not in line with the objectives of physics learning that must be possessed by students such critical thinking, curiosity, inquiry, and skills in real life. For solving problem in this observation, then the teacher triggering critical thinking skills, students can understand, solve physics problems, and apply learning concepts in everyday life. Also, seeing technological advances, especially Android, is a means for students that can be used as learning in class. Students are more likely to use smartphone in their daily activities. This makes it easy to use technology such as Android applications. One that can be used is the e-module android application so that students can use it anywhere and anytime such as Ashok Kumar Mittal in his speech stated that developing a good and effective diagnosis-based e-module which aims to identify deficiencies in understanding the concept of symmetry and Gauss Law. This diagnostic e-module works optimally to direct students' efforts to efficiently achieve a conceptual understanding the topic of symmetry and the Law of Gauss (Mittal, 2011). So, with the e-module, the students can better understand the concept of the material being taught, can analyze arguments, or answer a question by providing adjustments to relevant sources. The e-module application can make it easier for students in the learning process anywhere and anytime with efficient Android technology.

The method of this research used the Borg & Gall development procedure with nine phases (Borg & Gall., 1984). Data analysis that was used for this development research was descriptive, qualitative, and quantitative. The results of this development research showed that the e-module based on critical thinking skills on the heat & temperature material was developed by the indicators of critical thinking skills and the dimensions of knowledge that were visualized on the objectives, materials, activities, and evaluation questions which developed to improve learning outcomes. Based on the description above, it can be said that e-modules can improve students' critical thinking skills, to achieve an effective learning process and to create students critical thinking skills. So, a unique learning media was needed to attracted students in the teaching and learning process, as was done in this case about the development

of e-module based on Android on heat & temperature material.

The goals of this research, were:

1) Knowing the influence, the use of e-module application based on android on heat and temperature material to students' critical thinking skills at Public Senior High School 76 Jakarta and
2) Knowing the increase of critical thinking skills after using e-module application based on android on heat and temperature material for students at Public Senior High School 76, Jakarta.

This study was conducted to answer the question:

1) Is managing educational management by knowing the influence of website-based e-learning can improve student's creative thinking skills in pandemic era?

The hypothesis of this study is:

1) Managing educational management by knowing the influence of website-based e-learning can improve student's creative thinking skills in pandemic era.

LITERATURE REVIEW

The Quality of Education

The quality of education can be improved by how the education system works (Leontev et al., 2018). The quality of education can be improved and encouraged student development in various fields are priorities in improving the quality of education. Experiences in extensive learning will highly support the improvement quality of education (Goldman et al., 2018). The quality of education can be improved certainly by an experience, both the experience of educators and students. The experience possessed by educators will support the improvement of this education, as well as good experiences from students will make it easier for educators to provide direction in learning. So, improving the quality of education means an effort to develop abilities, attitudes that are worthy in all fields to support the education.

The small agreement between the implications and suggestions of the prominence of “quality” as the motivating factor for education planning, reform, and practice around the world. In most of the literature, the word “quality” is used in different way, expecting unanimity on what it implies. The desirability of different educational purpose and approaches promoted under the banner of quality without defining what it means explicitly. Whether the quality is defined explicitly or not, the education systems are continuously organized around a vision of quality (Harvey, 1995).

The change of education system is one of a rationale and a plausible justification of these concepts for education quality. The education quality and education system related each other. An education system can direct several or all of the visions of education quality, but both of them needs to be improved so that can improve the education itself (Kubow & Fossum, 2003).

In relation to improve the quality of education, teachers in this digital era must understand the conditions of the digital era 4.0 and learn more about students' mindsets, can think critically, have digital literacy, continue to learn new things, and must be able to take advantage of the opportunities of the Revolution Industry 4.0 to develop and improve a better and more meaningful learning process. One example that can be done is to combine learning activities in the classroom with several platforms or online sites (web) or through an android application. In addition, the development of learning media is also very necessary by utilizing this increasingly sophisticated technology. Utilization of learning media development in education 4.0 is expected to improve the quality of education with a significant role by teachers, students, and other figures who also play a role in this field. Utilizing technology in education can increase the effectiveness of the teaching and learning process, one of which is an Android-based e-module (Shahroom & Hussin, 2018). Thus, improving the quality of education can be done through the effectiveness

of e-module based on android.

E-Module Based on Android

A module is a book written with the aim that students can learn independently without or with teacher guidance, so that the module contains all the basic components of teaching materials (Majid, 2011). Can be synthesized a module is a teaching package that contains a unit of concepts from learning materials. The use of modules in the learning process can be applied as teaching materials that help teachers or educators make it easier to guide students in carrying out the learning process. Modules have several meanings regarding independent learning activities (Tim Direktorat Tenaga Pendidikan, 2008). The e-module has a function as an independent teaching material, a substitute for the function of an educator, as an evaluation tool, and as a reference material for students (Prastowo, 2011).

E-module is an electronic version of the module that is used through electronic devices such as computers, laptops, tablets, and smartphones. In addition, e-modules are also defined as independent learning media that can be filled with materials in the form of pdfs, videos, and animations so that they are able to make students active in learning. Another definition of e-module is a tool or learning tool to achieve the expected competence according to its complexity electronically (Zainul et al., n.d.).

The electronic module has almost the same characteristics as the module characteristics. The difference lies in the presentation using media such as images, videos, animations in conveying the material (Clark & Mayer, 2016). The characteristic of the electronic module is that it can contain simulative material. E-modules can present moving media in the form of animation or video. Another characteristic is that the e-module has a system that can run automatically, especially in learning evaluation. The speed to know the evaluation is very useful in learning. That way, if there is a problem in learning, the teacher can fix it quickly (Kementrian Pendidikan Nasional, 2010).

Previous studies which find the effectiveness of Digital book Android-based with material on heat & temperature on student learning outcomes. The average results of the students 'pre-test were included in the "fair" category, the average results of the students' post-tests were included in the "very good" and complete category so that they got N-Gain in the "medium" category. This shows that there was an increase in learning outcomes before and after the use of Android-based digital books on heat & temperature material (Putrawansyah & Sardianto, 2016). Furthermore, Afifah et al. (2018) stated that the e-module used in Kingdom Plantae learning was valid with a material validity value of 81.75% and 88.46 media. E-module with its practicality was obtained from the percentage value of the teacher's response with 88%, the small scale trial response was 83.05% and the trial was 88, 06% of the large scale and the effectiveness of the e-module was obtained from the pre-test and post-test values with an N-gain value of 0.61 (Afifah et al., 2018), and Roza Linda also said that on the development of interactive e-modules "The Chemistry Magazine" ionic equilibrium magazine and pH edition of the buffer solution and the solubility equilibrium edition were categorized as "valid" by the validator with a score of 93.75% and 94.45% (Linda, 2018). It can be concluded that in high school, an application can be made for learning companions such as e-modules which will be made especially for students who use a lot of time through their cellphones. This suggests that e-module has succeeded in improving student learning.

Muzayyanna (2018) also stated that the average score of students before using an Android based learning application only reached 65.0, while when using an Android-based learning application the average value achieved increased by 77.50. It can be seen from these results that the use of this learning method was considered very effective in helping students to attract and understand the material described in the application (Muzayyanna Zatulifa et al., 2018). Mobile Learning is more effective than using traditional teaching techniques. Also, there are many advantages and conveniences for teachers and students, such as supporting students to study independently and having more space, more time, and comfort to learn using this mobile learning method, besides that, students also find it easier to access their learning material. While the advantage for the teachers is that it is easier to control, supervise, deliver, and assess each student individually (Elfeky & Masadeh, 2016).

Critical Thinking Skills

The definition of 21st Century Skills includes: Learning and innovation skills (Creative and innovative, working innovatively and implementing innovative skills), Critical thinking and problem solving (thinking effectively and systematically, Making decisions and solving problems), Communication and collaboration (Communicating clearly and able to collaborate with others and also work in teams), Information, media and technological skills (information literacy, media literacy and ICT literacy), Life and career skills (flexible and adaptable, initiative and independent, able to socialize and interact between ethnic groups and ethnic groups) nation, Productivity and accountability, leadership and responsibility) (Trilling & Fadel, 2009). Critical thinking skills are one of the 21st century skills.

Thinking skills consist of four levels, namely: memorizing (recall thinking), basic thinking, critical thinking, and creative thinking (Krulik & Rudnick, 1995). Critical Thinking is essential as a tool of inquiry. As such, Critical Thinking is a liberating force in education and a powerful resource in one's personal and civic life. While not synonymous with good thinking, Critical Thinking is a pervasive and self-rectifying human phenomenon (American Philosophical Association, 1990). Critical thinking is a systematic thinking process that is important for a professional. Critical thinking will assist professionals in meeting client needs. Critical thinking means thinking with goals that help individuals make judgments based on data rather than estimates (Alfaro-LeFevre, 1999). In everyday life, critical thinking skills can be seen in the behavior and patterns of peoples' thinking, ability to focus on questions, analyze arguments, give an explanation or challenge, but still refer to the source. It can be concluded that critical thinking skills are a systematic group of phenomenon and professional thought processes. The implementation of critical thinking process in the field of learning does not encourage student to think critically. The factors that caused critical thinking do not develop in education, namely, first, the curriculum is designed with broad material objectives so that educators or teachers focus more on completing the material. Students who are equipped with critical thinking skills can observe the right or wrong opinions of others based on scientific truth and knowledge, so that students without any doubt can decide and judge which opinions are wrong and right. Critical thinking is important for someone to meet personal, social, and professionals who are always changing in society (Che, 2002). Partnership for 21st Century Skills identifies that critical thinking skills are one of the skills needed to prepare students for education and employment (S. Zubaidah et al., 2015).

Critical thinking is a mental process that is well organized in the decision-making process to solve problems. When students have good critical thinking skills, this will have an impact on understanding concepts that are good as well as being able to improve student learning outcomes. The use of interactive learning media can improve students critical thinking skills and students' mastery of concepts. As well as in inquiry learning at the laboratory an increase in the mastery of concepts as the effect from critical thinking skills of students (Akhyani et al., 2008). The use of inquiry-based effective friction teaching aids can improve critical thinking skills, it turns out that the results clearly affect improving student learning outcomes (Hartati, 2010).

Conceptual Framework

Education today really needs to train students to have critical thinking skills so that they have the ability to behave adaptively in order to face challenges and demands of everyday life effectively. To generate students' critical thinking by not seeing them as recipients of information but as users of information. By involving students actively can make students think more critically. In another way, involving students with e-modules can improve students' critical thinking (Snyder & Snyder, 2008). This e-module application can give students a sense of interest, so that students are more enthusiastic and active in learning in classroom. Electronic module is a form of presenting independent learning materials that are arranged systematically in the smallest learning unit to achieve a specific learning goal, which is presented in an electronic format (Adiputra et al., 2014). This application can also have a positive impact as a teaching material that can support students to be more independent and have a visualization that helps them to make a better understanding so that with this e-module based on android, students can develop strategies and tactics

in interacting with others and more quickly induce material concepts in e-module. The effectiveness of e-module based on android in this research can improve the students' critical thinking skills in pandemic era, also can improve the quality of education.

The explanation of education management in this research is about doing planning, organizing, actuating, and controlling as follows:

1) Planning: this research planned android-based e-learning.
2) Organizing: this research makes a schedule and the properties on this research (man, time, and hardware and software).
3) Actuating: all the activities of this research referred to the planning.
4) Controlling: all the activities of this research controlled by monitoring and evaluating at every stage of this research. And make revision if needed.

In this study using a mix method, namely Research and development method, and quasi-experimental research method. In the first stage, research and development was carried out on e-module based on android on temperature and heat material by following the Borg and Gall research method with 9 stages, consisting of nine steps including (1) research and information colleting, (2) planning, (3) develop preliminary form of product, (4) preliminary field testing, (5) main product revision, (6) main field testing, (7) operational product revision, (8) operational field testing, and (9) final product revision (Borg & Gall., 1984). After research and development method, or after step nine, then proceed to the second stage with a quasi-experimental method to determine the improvement of students' critical thinking by using an android-based e-module. In the control class, it is done using the printed module, while the experimental class is treated using an android-based e-module. Furthermore, can be seen at figure 1 below:

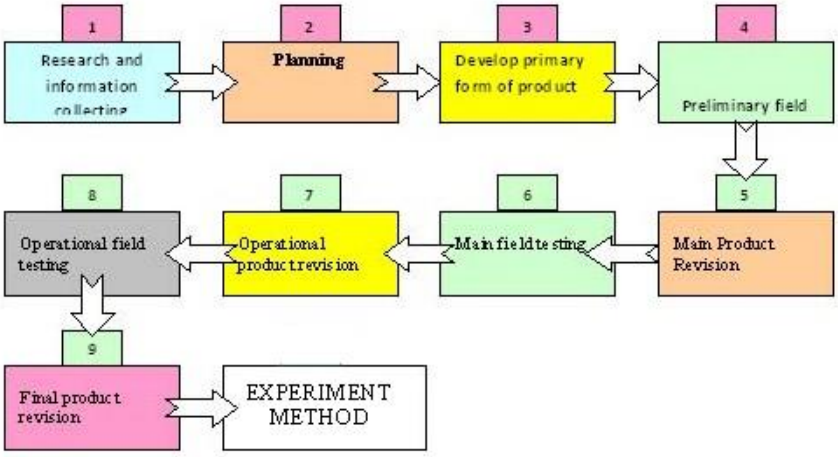

Figure 1. The Conceptual Framework

In this research focus on quasi experiment method and does not focus on research and development method.

METHODS

Research Design

This method was Quasi Experimental research with the design used is the Pretest-Posttest Control Group Design, namely one experimental class and one control class (Sugiyono, 2016). The experimental class was a class that is given treatment specifically, namely learning physics using an android-based e-module application, while the control class was given treatment using conventional learning using print modules at school. The conclusions of the results of this study were presented from the results of the analyst data. The purpose of this experimental study was to find the significant effectiveness of the treatment on increasing critical thinking skills. Verify the results were obtained by comparing the experimental class with the control class. In general, this experimental research model was presented

as follows:

$$\begin{array}{cc} Q_1 & X \quad Q_2 \\ \hline Q_3 & Q_4 \end{array}$$

Figure 2. Research Design of Quasi Experiment control group design (Sugiyono, 2016)

Where:
Q1 = Evaluation of the control class's pretest critical thinking skills
Q2 = Evaluation of the final stage of critical thinking skills (*posttest*) experimental class
Q3 = Evaluation of the control class's pretest critical thinking skills
Q4 = Evaluation of the final stage of critical thinking skills *(posttest)* experimental class
X = Treatment (*Treatment)* the use of an android based e-module application

This design used a quasi-experimental control group design. There were 2 classes in this. The control class was treated using a print module at Senior High School 76 Jakarta-Indonesia, in the experimental class using the heat and temperature e-module developed in this program. The meeting was held for 3 times, within 45 minutes. The pretest was carried out before the heat and temperature study, while the posttest was carried out after the heat and temperature study.

Population and Sampling

The population in this research was all students at Senior High School 76 X, XI, XII, Jakarta-Indonesia from August 2020 to December 2020, with total 601 students. The sampling technique used purposive sampling. It was said purposive because the taking of sample members from the population was done on the basis of time, energy, and cost considerations. Based on this, then taking a sample of all students of class XI and XII as the control class (n = 217) and class X as the experimental class (n = 197) at a Senior High School 76 Jakarta, totaling 414 students as research samples.

Figure 3. Research Samples at Class X, XI, XII Public High School 76 Jakarta, Indonesia

Previous empirical studies have found that teacher self-efficacy not only influences effective teacher teaching practices, it even leads to significant changes to the learning environment as a whole (Choi & Lee, 2018; Li & Liu, 2020; Poulou et al., 2019). The presence of ICT in the educational arena has changed teachers' perceptions of the

available abilities to generate a more effective teaching process. Coincidentally, teachers are advising to prepare for the boom of ICT integration in education. Effective use of ICT will support high student engagement and create a more dynamic learning environment (Hatlevik & Hatlevik, 2018). In this case, it becomes an obligation for teachers to form learning innovations that increasingly demanded in line with 21st-century learning.

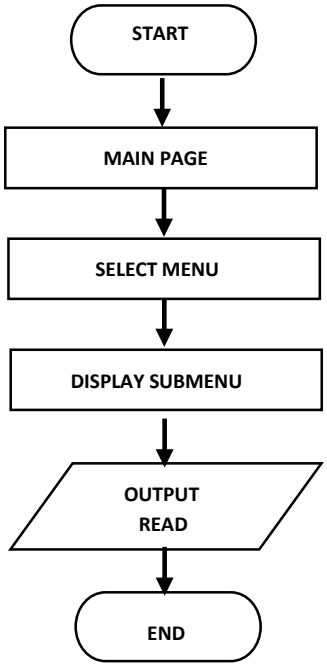

Figure 4. Android Based E-Module Flowchart

Information on the use of e-modules as follows:

1) Start. Open the application
2) Main page. Cover page display with a view to select the learning menu
3) Select menu. Select an existing menu
4) Submenu appears. Appear submenu select a submenu
5) Output read material. Shown material / read and worked on
6) End. Done

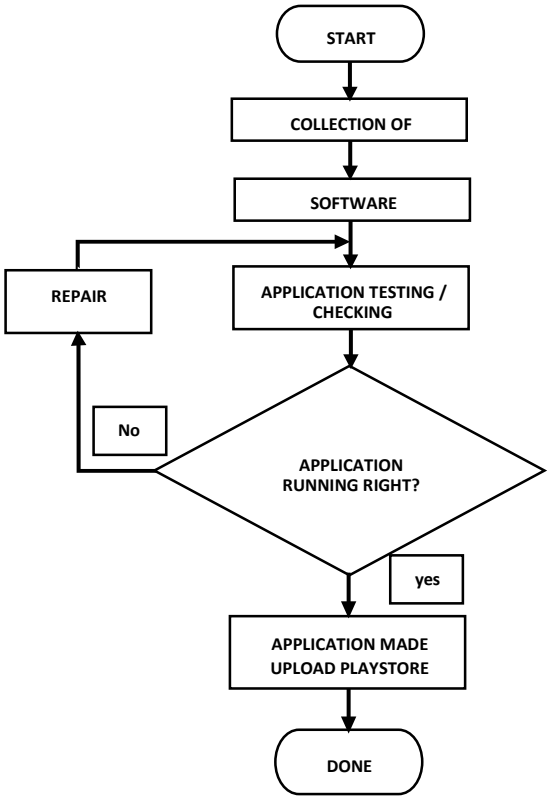

Figure 5. Stages of Making E-Module (IT Process)

Description of making the e-module-process, as follows:

1) Installing the software. Install java-runtime, install node-js, install cordova/phone-gap, install SDK android studio.
2) Making applications, with Cordova as the engine and framework7 as the UI framework (Using interface), checking applications using Android Studio as a simulator.
3) Checking the application: the application is in accordance with the material that was collected or not and has been running without error or not, if there is an error, then it is fixed. If there are no errors, then the application is correct.
4) Upload Play Store
5) Done.

Step to use the e-module:

1) Make sure android is connected to the internet.
2) Enter the e-module application.
3) Students register by filling in their name, email, password and selecting the student option.
4) Log in using your email and password.
5) Students can learn using the e-module.

Research Instruments

The instrument in this was a test whose results will be used to see if there is an effect on the critical thinking ability of the two samples. The instrument used is the Learning Implementation Plan (RPP), which was a learning implementation plan that is used to measure the value of student attitudes (as supporting data) and a description

test sheet to determine students' critical thinking skills. This test was used at the pretest and posttest in the form of essay questions as many as 10 pieces. The test was carried out twice, namely before the learning process (pre-test) and at the end of learning (posttest). Before being implemented, the items must be through a test in the form of a validity test.

Table 1
Grid of Critical Thinking Skills Instrument (Filsaime, 2008)

Critical thinking indicator	Critical thinking sub indicator	Question Number
Give a simple explanation (elementary clarification)	Focusing questions Analyze arguments Answer an explanation or challenge.	1,3,4
Build basic skills (basic support)	Adjusts to the source	2,7
Conclude (inference)	Induce / Consider definitions Consider the results of the induction	5,6
Provide further explanation (advanced clarification)	Defines terms and consider it.	8,9
Develop strategies and tactics (strategy and tactics).	Interact with other people.	10

Data Analysis Technique

The data obtained in this analysis was critical thinking ability data which was shown in the learning process using android-based e-modules. The data obtained were then analyzed by performing a normality test, homogeneity test, N-Gain test, and independent sample t-test. The normality test was carried out using a parametric statistical test, namely Kolmogorov Smirnov, using the help of the SPSS computer program. Homogeneity test was carried out using a parametric statistical test, namely the independent t-test. The Independent Sample t-test is used to determine whether or not there was an average difference between two unrelated sample groups. The N-Gain test to analyze quantitative data, namely the category of students' critical thinking ability tests, used a normalized gain score. The N-gain obtained from subtracting the pre-test score by dividing the final test score by the maximum score minus the initial test score. Then the t-table was looked from the t distribution table with α = 5% (Hake, 1999).

After all the analyzes were carried out, the questions were tested in both the control and experimental classes. There were two trials, namely pretest and posttest. The calculated variables were the average value of completeness and the percentage of critical thinking skills completeness with the following formula:

Mean value of the test results of the pretest and posttest critical thinking skills.

$$NR = \frac{\Sigma students\ total\ score}{\Sigma students}$$

Where, NR is the average value N-gain.
According to (Sundayana, n.d.) calculating the score $N\text{-}gain$, that is:

$$N_{-gain} = \frac{posttest\ score - pretest\ score}{ideal\ score - pretest\ score}$$

These values were then interpreted into the following classifications:

Table 2
Value Interpretation N-gain (Hake, 1999)

N-gain value	Criteria
g > 0.7	High
0.7 > g > 0.3	Moderate
g < 0.3	Low

After the t-test, the t-test effect size was calculated using the Cohen's d formula. The effect size was a measure of the magnitude of the effect of a variable on other variables, the magnitude of the difference and the relationship, which was independent of the size of the sample (Santoso, 2010). The formula for the effect size t-test was as follows (Thalheimer & Cook, 2002):

$$d = \frac{\overline{x_1} - \overline{x_1}}{S_{gab}}$$

$$S_{gab} = \sqrt{\frac{(n_1 - 1)S_1^2 + (n_2 - 1)S_2^2}{n_1 + n_2 - 2}}$$

Information:
$\overline{x_1}$ = experimental group mean
$\overline{x_2}$ = control group mean
With the criterion of d value of the effect size can be seen in table 3 below:

Table 3
Effect size table cohen's d (Cohen, 1988)

Category	Effect size (d)	Interpretation Cohen's Value
Small	0.20	58 %
Medium	0.50	69 %
Large	0.80	79 %

RESULTS

Previous study find the effectiveness of interactive physics e-modules to improve students' critical thinking skills resulted in the conclusion that the use of interactive e-modules can improve critical thinking skills and student learning outcomes. This is evident from the results of the t-test which shows a significant difference between students' scores before using the e-module and after using the e-module. Students' scores after using the interactive physics e-module were higher than before using the e-module (Sujanem et al., 2020). In this research the E-Module based on android can improve students' critical thinking skills then finally can improve the quality of education. So, this research has wider perspective.

Another previous study regarding the analysis of the need for physics e-modules to improve students' critical thinking skills, it is true that physics e-modules are needed in learning. In the research, it is stated that this e-module can improve student learning outcomes, long-term knowledge, problem solving abilities, and also critical thinking skills. Learning with this e-module can also help change teacher-centered learning methods to student-centered learning (Rahmawati et al., 2021). The e-module in this research is improving the students' critical thinking skills and also improve the quality of education. Assessment of the quality of education, in this case, is an instrument to obtain objective and valid information about the conditions and results of the educational process, to determine the effectiveness of e-module based on android on heat and temperature topics for improving the critical thinking skills of the student in a pandemic era. Thinking skills consist of four levels, namely: memorizing (recall thinking), basic thinking, critical thinking, and creative thinking (Krulik & Rudnick, 1995). The effectiveness of e-module based on android in this research can improve the students' critical thinking skills in pandemic era, also can improve the quality

of education.

Research conducted by Risdianto et al (2020) regarding modules in students' critical thinking skills, instruments to test teacher perceptions of modules for students' critical thinking skills were declared valid on all questions used and reliable with Cronbach's Alpha value of 0.925 (Risdianto et al., 2020). Meanwhile, the instrument in this research was a test of students' critical thinking ability first to find out whether or not the question is appropriate for use. In order for the instrument used to be valid and reliable, a validity test was carried out on each item in the question. At a significant level of 0.05 or 5% for a sample of 197 respondents, it was obtained r table of 0.308 and r count of 0.576 based on the calculation of the validity of the critical thinking ability test items from 15 items in the description, 10 items were declared valid and 5 items were declared invalid (drop) so that it is designated as a means of collecting data.

The calculation of the reliability of the students' critical thinking ability test items for 197 samples and the alpha significance level of 0.05, the r table value was 0.308 while the r count value was 0.675, thus, the r count was greater than the r table, so it could be stated that the thinking ability test instrument critical heat and temperature are declared reliable. Based on the results of testing the level of reliability of the test items and referring to the specified criteria, the reliability of the test items on the critical thinking ability of heat and temperature with a calculated r value of 0.675 is in the high category.

The first check on the data that has been obtained was relevant enough to the research carried out. Checking was done by using normality test (with Kolmogorov-smirnov), homogeneity test (with Levene's test) and t-test on SPSS and obtained results in the following table:

Table 4
Data Normality Test Results

Test Group	n	Statistics Test Sig.	Information
Experimental class score gain	197	0.199	Normal
Gain control class score	2217	0.128	Normal

The results in table 4 show that the significance value of the Kolmogorov-Smirnov test for the experimental class score gain data was 0.199 where the significance value shows that it was greater than the α value (0.199> 0.05), so it can be concluded that the data owned was normally distributed. As for the data gain, the control class score was 0.128 where the significance value shows that it was greater than the α value (0.128> 0.05), so it can be concluded that the data owned was normally distributed. Because the two data are normally distributed, the next step is to do the homogeneity test.

Table 5
Homogeneity Test of Experiment Class

Levene Statistics	df1	df2	Sig. (α)
1.836	4	299	0.122

The homogeneity test of the two treatment classes in this research was carried out by calculating $Fratio$ between the largest variance and the smallest variance of the class being tested, namely by dividing the largest variance by the smallest variance then comparing the value $Ftabel$ at the significance level α = 0.05. Based on table 5, the data was obtained sig. amounting to 0.122, because the sig. greater than the value of α (0.122> 0.05), then the decision taken was to accept Ho, this means that the sample comes from homogeneous data. The results of the t-test for the experimental class and control class based on the SPSS calculation (Table 6) were as follows:

Table 6
t-test of Experiment Class

	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
Equal variances assumed	3.010	.086	2.533	68	.014	7.314	2.887	1.551	13.077
Equal variances not assumed			2.533	58.9	.014	7.314	2.887	1.535	13.093

From the data table 6, the results of the SPSS showed that the value of t = 2.533 (t-count). The results of the difference between t-count and t-table can be seen in table 7.

Table 7
The results of the t-test and t-table analysis

Test Group	Average	Test Statistics			Information
		dk	t-count	t-table (α=0.05)	
Experimental class score gain	19,543	68	2.533	2.021	Different
Controll class score gain	12,228				

Based on table 7, the average gain score of the experimental group was 19.543 and the average gain score of the control class was 12.228. The mean gain of the experimental class score was higher than the gain average score of the control class. The N-gain score equals to 0.85, which means in high category.

Based on the results of the test statistics for the experimental and control class were obtained t_{score}= 2,533> t-table = 2,021 at α= 0.05. There was a difference in the score gain of students' critical thinking skills between the experimental class and the control class, meaning that the class using the android-based e-module application shows an increase in critical thinking skills compared to classes that do not use android-based e-module. The differences that occurred in the control class using the simple print module were that the students were not able to provide simple explanations, did not build basic skills, did not conclude, did not provide further explanation, and were not good at developing strategies and tactics. While the experimental class that uses android-based e-modules, the incident was that the students are quite good at providing simple explanations, both building basic skills, and quite well concluding, good enough to provide further explanation, and good enough strategy and tactics. This was in accordance with the results of the quantitative calculations above.

So, the conclusion was that the results of students between classes given an android based e-module application in learning with a class using the print module are different, where the class using the android-based e-module application was better at working on a problem than students in the class using print module. This was because the android-based e-module provides more information about the material, was broader and deeper, can be accessed at any time using a cellphone.

The magnitude of the influence of the android-based e-module application in solving critical thinking skills test

questions at Public Senior High School 76, class X, XI, XII, Jakarta-Indonesia can be seen by calculating the effect size using Cohen's formula as follows:

$$S_{gab} = \sqrt{\frac{(197-1)173{,}3086 + (217-1)64{,}891}{197+217-2}}$$

$$S_{gab} = \sqrt{\frac{(196)173{,}3086 + (216)64{,}891}{412}}$$

$$S_{gab} = \sqrt{\frac{33968{,}4856 + 14016{,}456}{412}}$$

$$S_{gab} = \sqrt{\frac{47984{,}9416}{412}}$$

$$S_{gab} = \sqrt{116{,}4683}$$

$$S_{gab} = 10{,}792$$

Thus, the effect size in this case was

$$d = \frac{19{,}543 - 12{,}228}{10{,}792}$$

$$d = \frac{7{,}315}{10{,}792}$$

$$d = 0{,}68$$

Based on these calculations it can be concluded that the magnitude of the influence of the android-based e-module application in solving the critical thinking ability test questions in Public Senior High School 76, class X, XI, XII, Jakarta-Indonesia d equal to 0.68 (medium-large), in the Cohen's value interpretation table, 75.1% was classified as moderate.

DISCUSSION

Based on research developed by R Ilmi, et al (2021) regarding e-modules that can be operated on Android-based smartphones, that e-modules are valid, practical, and effective in learning. The practicality of this e-module is based on the results of the teacher and student response. Teachers and students can use this e-module easily and make it easier for students to understand the learning material. Students' learning completeness after using e-modules has also reached the standard of learning completeness (Ilmi et al., 2021). Based on Risdianto et al (2020), one of the tips to practice students' critical thinking skills is the use of teaching materials that are developed based on indicators of critical thinking (Risdianto et al., 2020). So, it is necessary to develop a module to train students' critical thinking skills. Based on research by Matsun et al (2019) regarding e-module based on culture wisdom, the e-module is very viable for use in learning. The effectiveness of e-module was tested using paired sample t test. The results showed no effect of the use-based e-modules of local wisdom to the learning process of physics. Values of N-Gain score indicates the percentage of 81% (in the effective category). E-modules used in their study utilizes the android-based smartphone technology (Matsun et al., 2019). These mean that the use of Android-based e-modules can also be used in physics learning to improve the quality of learning and widely the quality of education.

The use of Android-based e-module applications on heat and temperature material on student's critical thinking skills at Senior High School 76 Jakarta. Electronic modules or often known as e-modules were a form of teaching material that was in accordance with the characteristics of teaching materials that have been packaged in a unified whole,

which were arranged systematically to be studied independently and more actively by students according to their speed or ability without guidance from the teacher.

To produce a module that can increase learning motivation, module development must pay attention to the characteristics required (Widodo & Jasmadi, 2008), namely:

1) Self-instructional
   It was an important characteristic in the module, with this character allowing a person to learn independently and not depending on other parties. To fulfill the character of self-instruction, the module must:
   a) Contains clear learning objectives and can describe the achievement of basic competence.
   b) Contains learning materials that are packaged in small/specific activity units, making it easier to study them thoroughly.
   c) There are examples and illustrations that support the clarity of the presentation of the learning material.
   d) There are practice questions, assignments and the like that make it possible to measure students' mastery.
   e) Contextual, namely the material presented related to the atmosphere, task or context of activities and the environment of students.
   f) Using simple and communicative language.
   g) There is a summary of the learning material.
   h) There is an assessment instrument, which allows students to carry out self-assessment.
   i) There is feedback on students' assessments, so that students know the level of mastery of the material.
   j) There is information about referrals/enrichments/references that support the learning material in question.
2) Self-contained
   The module was said to be self-contained when all the learning material needed is contained in the module. The purpose of this concept was to give students the opportunity to study the learning material thoroughly, because the learning material was packaged into a complete unit. If it was necessary to divide or separate material from one of basic competence, it must be done carefully and pay attention to the extent of the basic competency that students must master.
3) Stand alone
   Stand alone or standing alone was a module characteristic that does not depend on other teaching materials/media or does not have to be used together with other teaching materials/media. By using modules, students do not need other teaching materials.

Critical thinking can be said to be a reflective thinking skill to decide things to do where the critical thinking skills of each student are not the same, therefore critical thinking skills in the learning process need to be trained and developed by the teacher (Siti Zubaidah, 2010).

The use of android-based e-module applications on heat and temperature material on students' critical thinking skills at 76 Jakarta Senior High School works optimally to make students achieve conceptual understanding of the topic of heat and temperature efficiently, so that with e-modules students are able to understand the concept of the material being taught and can analyze arguments or answer an explanation. This e-module application also helps students in hand-held learning, no longer a printed module that provides one-way learning as we already know that e-modules must provide two-way learning with reciprocity and interactivity. Based on research conducted by Amrullah et al. (2017) regarding Android-based e-modules, the e-modules developed did not produce significant differences in students' conceptual understanding compared to classes that did not use e-modules. Students' independence in learning is also not much different when using e-modules and not, this is due to teacher-centered learning habits. The E-module based on android can improve students' conceptual understanding (Amrullah et al., 2017). If compared

with Amrullah's research, the e-module developed in this research has the advantage of increasing students' critical thinking skills after using the e-module.

Increasing critical thinking skills after using the android-based e-module application on heat and temperature material for students at 76 Jakarta Senior High School

Android-based e-module teaching materials are able to train student's critical thinking skills, as evidenced by the gain results which provide an overview of increasing the critical thinking skills between before and after learning using e-modules. Based on table 7, the mean gain score of the experimental group at Public Senior High School 76, X, Jakarta-Indonesia was 19.543 and the mean gain score for the control class at Public Senior High School 76, XI, XII, Jakarta-Indonesia was 12.228. The mean gain of the experimental class score was higher than the gain average score of the control class. Research conducted by Suwatra et al (2018) regarding the development of interactive e-modules to improve students' critical thinking skills on global warming material, this e-module succeeded in increasing critical thinking skills as evidenced by the average of N-gain of experiment class is higher than control class, that is 0.77 for the experimental class and 0.55 for the control class. The ability of critical thinking skills on global warming for the experimental class increased significantly by 95% (Suwatra et al., 2018).

This android-based e-module was used as teaching material in accordance with the opinion (Suarsana, 2013) that it must have an interactive nature to facilitate navigation, allow loading of images, audio, video, and animation and is equipped with formative tests or quizzes. Using an android-based e-module application on the topic of heat and temperature is more effective in increasing critical thinking skills than using a simple print module. So it can be said that the android-based e-module makes it easy to load various kinds of images, videos, even to animation. If e-modules were used in this material students will experience interactive activities that allow students to think creatively and critically, not only that student will be happier in studying the material and feeling boredom for learning will be reduced.

Based on the results of interviewed with two physics subject teachers at Public Senior High School 76 Jakarta-Indonesia, teachers still dominate in the classroom and function as the main source of knowledge. Teacher innovation and creativity in utilizing learning media were also not optimal. The physics learning process has used sufficient media. However, it has not been used optimally, this can be seen from the daily test value on heat and temperature material, less than 40% which was declared to meet the completeness standard while the test was stated not to meet the completeness standard for physics subjects.

One student expressed that he prefers physics learning using media in the form of animated Power points because learning was more interesting and less boring than using the lecture method. Learning like this pays less attention to student activity, student interaction and knowledge construction. So that students quickly become bored with physics lessons and lack of motivation towards learning physics, especially abstract ones, this results in low critical thinking skills of students so that the application of heat and temperature material in real life was not optimal. In order to achieve an effective learning process and to foster student's critical thinking skills. So unique learning media was needed so that it can attract students in the teaching and learning process. One of them was the e-module media based on android heat and temperature material. So, with the existence of android-based e-module with critical thinking components and supported by critical thinking skill questions in it, it was hoped that there will be an increase in student's critical thinking skills.

There were 414 students as the subject of this research at Public High School 76, class X, XI, XII, Jakarta-Indonesia, from August 2020 to December 2020. This research used the purposive sampling technique with 197 students (class X) as the experimental class using e-module based on android and 217 students (108 students in class XI and 109 students in class XII) as control class using a simple printed module in this school.

Based on the results of the t-test calculation between the experimental class and the control class at Public Senior High School 76 Jakarta, it illustrated that the critical thinking skills of students who learn using android-based e-

modules were different from those who do not used e-modules. The critical thinking skills of students in the experimental class at Public Senior High School 76, class X as experimental class is higher than class XI, and XII as control class. It can be seen from the calculated data that the average score increases in the pretest and posttest results of the experimental group was higher than the control group. Compared with other research conducted by Seruni et al (2020) regarding e-modules with problem-based learning to improve students' critical thinking skills, the conclusion is that e-modules can indeed improve students' critical thinking skills. This is evident from the results of the Wilcoxon match pair test conducted using SPSS. The results obtained Asymp. Sig. (2 tailed) is worth 0.000 < 0.05. This means that there is an increase in students' critical thinking skills in the pre-test and post-test after learning to use e-module media (Seruni et al., 2020).

In this research, the effectiveness test results illustrated that android-based e-modules can train students' critical thinking in class X Public Senior High School 76 Jakarta as experimental class with a contribution of 8.6%, and in class XI, and XII Public Senior High School 76 Jakarta as control class by 6.1%. Pictures, videos, animations, and simulations can help students to learn concepts related to heat and temperature. The video that was presented encourages students to understand the discussion described in the e-module, the number of images supports real understanding, and with the simulation students can experience different experiences. Based on the results, it showed that students feel very interested, and it was easier to understand the concept with interactive e-module presentations. The effectiveness of the e-module was supported by the evaluation tools presented. Evaluation was used to measure students' critical thinking skills. Evaluation was arranged based on the material presented. The advantages of the e-module being developed were in material that was widely discussed with real-life concepts, that in high school learning an application can be made for learning companions. Especially for students who spend a lot of time on their cellphones. It is in line with previous studies about effectiveness of an e-module at teaching novice learners critical thinking skills, states that e-module was helpful in starting new material as learning tool, because it has flexibility for student to re-learn the previous materials while they learn the new materials. The use of e-module can also engage the students by its interactive features. (Koth et al., 2021). So that with this media, it can improve student's critical thinking skills (Linda, 2018). The E-Module in this research can improve the students' critical thinking skills in giving a simple explanation, building basic skills, concluding (inference), providing further explanation, developing strategies and tactics.

The magnitude of the influence of the android-based e-module application in solving critical thinking skills test questions in Public Senior High School 76, class X, XI, XII can be seen by calculating the effect size using Cohen's formula. Based on these calculations it can be concluded that the magnitude of the influence of the android-based e-module application in solving the critical thinking ability test questions in Public Senior High School 76, class X, XI, XII, the cohen's d was 0.68, in the interpretation table Cohen's value was 75.1% which was classified as moderate. This result is in line with the research conducted by Rustana, et. Al (2021) showed that the e-module can enhance the students' higher order thinking skills as shown by the cohen's d value was 0.64 categorized as medium (Rustana et al., 2021). In this research, the e-module enhanced the students' critical thinking skills and the cohen's d value was higher (0.68 > 0.64).

Another previous study about Effectiveness of E-module integrated with Pancasila character values, states that the experiment class which learned with the E-module, obtained an N-gain value of 0.71 (High) criteria. The effectiveness of E-Module has cohen's f value or effect size value of 1.21 in very strong category in improving the students' critical thinking skills (Al-BiRuNi, 2021). If compared with Al-BiRuNi's research, the e-module developed in this research has the advantage of increasing students' critical thinking skills after using the e-module on work and energy material. In this study, the N-gain value of 0,85 (high) criteria. The effectiveness of E-module has cohen's d value of 0,68 (medium-large).

Weaknesses when using this Android-based e-module, namely, must have an internet connection for the installation stage, the availability of memory or storage space on an Android device, adequate equipment and the ability to use applications on Android.

LIMITATION

This study has limitations, this e-module is only supported on Android and not yet developed for iOS. Maybe later can continue for future research. The e-module in this research only focuses on improving students' critical thinking skills, even though it can expand with creative thinking skills, High Order thinking skills, and others. This research was conducted during the pandemic era, so it was done by distance learning. Maybe similar research can be done later after the pandemic era with classroom learning. In this research focus to improving the students' critical thinking skills with effectiveness of e-module based on android which can improve the quality of education. This study does not focus to the research and development of the e-module.

CONCLUSION

Based on this research, the use of android-based e-module applications on the topic of heat and temperature were more effective in increasing critical thinking skills compared to using simple print modules. Evidenced by The magnitude of the influence of the android-based e-module application in solving critical thinking skills test questions in Public Senior High School 76, class X, XI, XII, Jakarta was 0.68, in the interpretation table Cohen's value, 75.1% was classified as moderate, this result was caused by the ease of downloading the e-module application in smartphones which owned by students and used for the teaching and learning process on the topic of heat and temperature can improve student's critical thinking skills. So, the quality of education through effectiveness of e-module based on android can improve the critical thinking skills of students in pandemic era.

ETHICAL STATEMENT

The Statement of Ethics to conduct research with a sample of class X, XI, XII high school students at Public High School 76 Jakarta have been carried out with the correct procedure. The principal of the school has allowed us to do this research, and already allowed by student's parent. Because this research conducted and assisted by the teacher at the school. This research was conducted during online learning in the classroom.

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