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Improving Elementary School's Critical Thinking Skills through Three Different PBL-Assisted Learning Media Viewed from Learning Styles

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Abstract

This research aims to analyze (1) the differences in critical thinking skills among students who were given three different PBL-assisted learning media; (2) the differences of critical thinking skills among visual and auditory students; and (3) the interaction between the three different learning media with learning styles on students' critical thinking skills. This research is a quasi-experiment with a pretest-posttest non-equivalent control-group design. The population in this research is the fifth-grade students of the elementary school in Jebres Sub-district, Surakarta, Indonesia. The sampling technique used is cluster random sampling obtaining 96 students in three experimental classes at different schools. The data of critical thinking skills are gained from test scores. The data analysis technique used is descriptive quantitative statistics through ANCOVA test with the 3 x 2 factorial design. The results of the research revealed that there are different skills in critical thinking in different learning media. The highest skills in critical thinking are reached by students who were given differentiated problem-based learning (PBL) with multimedia in their learning. There are also differences in critical thinking skills between visual and auditory students.

KEYWORDS: Critical Thinking Skills, Problem-based Learning, Multimedia, Learning Style

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1. Introduction

The Ministry of Education and Culture of the Republic of Indonesia has made various efforts in improving 21st century skills, including the implementation of the 2013 curriculum.

According to the Minister of Education and Culture Regulation number 57 of 2014, the 2013 curriculum for elementary schools contains learning skills and content in a theme that refers to the spiritual, social, knowledge, and skill core competencies (Rumahlatu et al., 2016). The 2013 curriculum is an integrated thematic learning that develops learning content into one theme and is integrated starting from the background, subject characteristics, core and basic competencies, learning design and model, assessment, media, learning resources, and the teacher's role in learning (Farisi, 2013). This is in line with Dewantara's opinion (2020) which states that thematic learning is mixed learning that uses themes to connect several subjects related to the aim of providing meaningful experiences for students. Thematic learning integrates attitudes, skills and knowledge by using themes that contain holistic learning material and is focused on everyday life (Narti et al., 2016).

The 2013 curriculum requires students to be able to master technological developments and emphasize the importance of 21st century skills. Critical thinking skills are one of the most important life skills for humans in the 21st century. These skills are considered as the main key to achieve goals for a new knowledge-based economy (Jones & Pimdee, 2017; Changwong et al., 2018). Thinking skills describe not only the ability to think according to the rules of logic and possibility, but also the ability to make decisions or solve problems in real life and society (Zulmaulida et al., 2018; Murawski, 2014; Karakoc, 2016).

Critical thinking is a process for analyzing, assessing, and evaluating arguments, claims, and evidence with deductive and inductive reasonings in order to solve a problem, decide, or make a conclusion (Halpern, 2003; and Facione, 2015). Furthermore, critical thinking is the ability to be open-minded by sorting information, formulating hypotheses, analyzing, synthesizing, and evaluating basic evidence correctly (Changwong et al., 2018; Karakoc, 2016).

Paul & Elder (2008) state the characteristics of critical thinkers as being able to ask important questions and problems, gather and assess relevant information, conclude and find reasonable solutions, being open-minded with alternative thinking systems (many possibilities), and communicating effectively with others so that they are able to solve complex problems. The indicators of critical thinking skills according to Ennis (1993) include (1) formulating the main problems, (2) revealing facts, (3) choosing logical arguments, (4) analyzing the problem from a different perspective, and (5) drawing conclusions. The indicators of critical thinking skills proposed by Facione (2015), namely interpretation, analysis, inference, evaluation, explanation, and self-regulation, are used in this research.

Learning in schools should be able to develop students' critical thinking skills. Strategies, approaches, models or methods, and learning media that facilitate the process of transferring information, generating student activity and describing problems in daily life must be used in learning.

Ideal learning to develop students' critical thinking skills is learning that provides controversial ideas, authentic problems or issues that are familiar to be solved (Ruggiero, 2012; Murawski, 2014). This causes individuals to be active and skilled in conceptualizing, applying, analyzing, synthesizing, and evaluating information to get the answer or conclusion (Costa & Kallick, 2014).

Problem based learning (PBL) is a learning model that is suitable for building students' new knowledge through investigation of solutions to problems as well as meaningful and self-motivating learning (Lambros, 2004). Barrows (1986) defines the concept of problem-based learning that was coined around 1996 as student-centered learning and the effort in developing problem-solving skills based on real-life problems provided by the teacher as a facilitator by emphasizing contextual and cognitive learning. The skills acquired by students through problem-based learning are problem-solving skills, critical thinking skills, teamwork and the skills to work independently (Barrows & Tamblyn, 1980).

This is in line with the opinion of Baysal (2017) and Boud & Feletti (1997) stating that problem-based learning is a learning model that actively engages students in authentic problem solving from real life, develops various student skills such as communication, problem solving, and critical thinking, and increases learning collaboration and motivation.

The following are the 7 stages of the PBL learning model adapted from Barrows & Wee Keng Neo (2010): (1) orientation, (2) encountering the problem, (3) tackling the learning issues, (4) reiterating and reassessing the problem, (5) summarizing and knowledge abstraction, (6) evaluating groups, and (7) evaluating tutors. Lambros (2002) states that collaboration in groups is a PBL element needed in solving problems through the form of peer support, recognition and reinforcement of knowledge, assistance of others in synthesizing new information in order to build activities that are of interest to students.

The application of the PBL model will be more effective if combined with a variety of supporting learning media. This research compares the use of modules, picture media, and multimedia assisted by the PBL model. Modules are learning materials that are arranged systematically in a language that is easily understood and positively influences students' cognitive and affective skills according to their characteristics (Dimopoulos et al., 2009; Lohfink et al., 2014). Handayani (2018) concludes that the problem-based learning module is effective in significantly increasing students' cognitive and psychomotor learning outcomes. In addition, the module is considered effective in facilitating visual learning. It can improve reflective abilities, learning achievements, and science process skills of the students (Alias, 2012; Martiningsih et al., 2019).

Furthermore, picture media are not only part of the teaching strategy but are part of the students' learning experiences through two-dimensional representations of various objects such as places, objects, people, activities, events etc. (Shabiralyani et al., 2015; Dewan, 2015). Pictures are considered better than just concrete words because they can present the intended object. Jamal and colleagues (2019), Inel & Balim (2013) and Balim and colleagues (2016) conclude that there is a positive effect of the use of comic-picture or cartoon-concept media on the problem-based learning process, including improving students' creative and critical thinking skills, improving learning outcomes, and making learning interesting and enjoyable for students.

Furthermore, multimedia is a combination of various types of digital media such as texts, images, audio, and video into an interactive verbal information application or presentation with the aim that messages or learning materials can be optimally accepted by students who have different modalities (Molina et al., 2018; Jastaniyah & Bach, 2017; Arkorful & Abaidoo, 2014). Several researches have shown that the use of PBL-based multimedia can improve students' critical thinking skills (Neo & Neo, 2001; Nirbita et al., 2018; Hussin, et al., 2019).

In addition to the application of learning models and instructional media, teachers must also consider the

characteristics of students which would affect the course of the learning process. One of the characteristics of students that influences the effective use of instructional media is learning style. Not all learning styles are suitable with the application of certain learning media, and vice versa, not all learning media can facilitate all students' modalities. This is in line with the opinion of Gokalp (2013) that learning styles affect students' abilities in the learning process. Moffyza & Heong (2014) and Myers & Dyer (2006) define learning styles as characteristics of an individual's tendency to adopt strategies in receiving, collecting, organizing, and processing information in the learning process. DePorter and collegues (2007), known as an expert in the development of the learning method based on learning styles, suggest three types of learning styles, including (1) visual, (2) auditory, and (3) kinesthetic styles. This research compares students' skills with visual and auditory learning styles.

Several previous researches have analyzed the effect of learning media on students' critical thinking skills (Nirbita et al., 2018; Twiningsih et al., 2019) and the effect of learning styles on students' critical thinking skills. However, there is no research that analyzes the effect of three different learning media assisted by the PBL model and their relations to learning styles on students' critical thinking skills. Based on the background above, this research aims to (1) the differences in critical thinking skills among students who were given three different PBL-assisted learning media; (2) the differences of critical thinking skills among visual and auditory students; and (3) the interaction between the three different learning media with learning styles on students' critical thinking skills.

2. Materials and Methods

This research is a quantitative research of a quasi-experimental type. A quasi experiment is a form of experimental research where individuals have been assigned to groups randomly so that the researcher used classes with this condition as an experimental group (Creswell, 2012). The main purpose of this experimental research is to investigate the possible cause and effect by applying treatments to the experimental group I (module), II (pictures), and III (multimedia), and then comparing the results of these treatments.

This research uses a pretest-posttest non-equivalent control-group design with the 3 x 2 factorial design. The non-equivalent control-group design was chosen because this research provided treatments to groups that are comparable in terms of academic achievement, curriculum, and school facilities and are selected through random sampling (Oakes & Feldman, 2001). The pretest-posttest design was used to compare the experimental groups and measure the level of change that occurred as a result of the treatment (Bonate, 2000).

The independent variables of this research include PBL-assisted learning media, consisting of multimedia, picture media, and modules, and learning styles, consisting of visual and kinesthetic learning styles. The independent variable in this research is critical thinking skills. The 3 x 2 factorial design can be seen in Table 1.

		Learning Media (A)		
		PBL Module (A_1)	PBL Picture (A_2)	PBL Multimedia (A_3)
Learning Styles (B)	Visual (B_1)	$B_1 A_1$	$B_1 A_2$	$B_1 A_3$
	Auditory (B_2)	$B_2 A_1$	$B_2 A_2$	$B_2 A_3$

Table 1 - Factorial design 3 x 2.

The population in this research included all fifth-grade students of elementary schools in Jebres District, Surakarta, Indonesia.

The sampling technique used was cluster random sampling. This technique was chosen because the population does not consist of individuals but rather groups of individuals or classes (Alvi, 2016). The stages of implementing random cluster sampling include selecting elementary schools according to the criteria of implementing the 2013 curriculum, having comparable achievements, and having fairly complete facilities and Then using a lottery in the form of rolls of paper, on which the name of each elementary school is written, the researcher determined the module, picture, and the multimedia classes.

There were 96 sample students in this research, consisting of 31 experimental-class-I students, 34 experimental-class-II students, and 31 experimental-class-III students. Furthermore, there were 58 visual students and 27 auditory students. The fifth grade of SDN Gulon is a control class taught with PBL-assisted modules. The experimental class consisted of the fifth grade of SDN Tugu Jebres taught with PBL-assisted picture media, and the fifth grade of SDN Sabrang Lor taught PBL-assisted multimedia.

This research was conducted from August to October 2019 in elementary schools which implemented the 2013 curriculum with thematic learning. The learning materials in this research include Theme 1: Animal and Human Motion Organs (consisting of Subtheme 1, Animal Motion Organs, Subtheme 2 Animals, Humans, and Environment, and Subtheme 3 Environment and Its Benefits) and Theme 2 Clean Air for Health (consisting of Subtheme 1: How the Body Processes Clean Air, Subtheme 2 The Importance of Clean Air for Respiration, and Subtheme 3 Maintaining Human Respiratory Organs).

The instrument used to measure students' critical thinking skills was 8 open-ended questions that were in accordance with the indicators of critical thinking skills proposed by Facione (2015). These open-ended

questions were assessed with a score range of 0-5. The learning style questionnaire instrument by DePorter and colleagues (2007) was used to classify students' learning styles.

The instrument was tested for its validity and reliability first. The validity test was divided into two, content validity and empirical tests. The content validity test was performed by testing the instrument to the expert. The face and format of the instrument were tested by the educational evaluation expert, the grammar was tested by the linguist, the suitability of the instrument with the level of development of child psychology was tested by the child psychologist, and the suitability and accuracy of the instrument with indicators of critical thinking skills were tested by the expert of critical thinking skills. The empirical validity of the instrument was measured using a statistical correlation analysis technique with the Product Moment test. The instrument's reliability was tested using the Conbrach Alpha's test. The hypothesis prerequisite tests consist of the normality test using Kormogolov Smirnov's test and the homogeneity test using the Levene's test. The hypotheses were tested using the covariate analysis (ANCOVA) test.

3. Results

The hypothesis tested in this study were: (1) there is a difference between students' critical thinking skills who were given three different PBL-assisted learning media; (2) there is a difference between visual and auditory critical thinking skills; (3) there is an interaction between the three different learning media with learning styles on students' critical thinking skills. The data of critical thinking skills were obtained from the results of the students' pretest and posttest. The data prerequisite tests were done through the normality test with Kolmogorov-Smirnov's One-Sample Test and the homogeneity test with Levene's Test of Equality of Error Variances. Normality test was conducted to find out whether the sample obtained is from a normally distributed population or not. A summary of the results of the normality test can be seen in Table 2.

Group of Data	N	Normality Test		Conclusion
		p-value	Sig.	
Pretest	96	0,197	0,05	Normal
Posttest	96	0,252	0,05	Normal

Table 2 - The summary of the normality test results.

Based on Table 2, it can be concluded that the data of critical thinking skills are normally distributed because p-value > sig. 0.05. After the data were declared as normally distributed, the next step was the homogeneity test. The homogeneity test was used to determine whether the sample comes from a homogeneous population or not. The summary of homogeneity test results can be seen in Table 3.

Levene Statistic	df_1	df_2	p-value	Sig.	Conclusion
1,832	1	168	0,178	0,05	Homogen

Table 3 - The summary of the homogeneity test results.

The homogeneity test results in Table 3 produce p-value > sig. 0.05. Thus, we can conclude that the data variance comes from a homogeneous population.

After the data had been proven to be normally distributed and consist of homogeneous variance, the next step was the ANCOVA test. Hypothesis testing in this research used the two-way Anova formula with 3 x 2 factorial design. The purpose of this analysis is to examine the effect of independent variables on the dependent variable. The hypothesis test decision is determined by criteria: if the p-value < 0.05, then the null hypothesis (H_o) is rejected or (H_1) is accepted. The results of the ANCOVA analysis regarding the effect of the research variables can be seen in Table 4.

Source	df	Mean Square	F	Sig.	Conclusion
Pretest	2	1711,028	7,427	0,001	H_0 accepted
Learning media	2	2794,284	10,079	0,000	H_0 accepted
Learning Styles	1	2881,707	10,395	0,002	H_0 accepted
Learning media* learning style	3	3077,201	11,100	0, 000	H_0 accepted

Table 4 - The summary of Ancova results.

Based on Table 4, it can be seen that there are difference students' critical thinking skills based on Sig. pretest 0.000 < 0.05. The hypothesis test decision 1 is H_o is rejected or H_1 is accepted because the p-value of 0.000 < 0.05. Therefore, the use of three different learning media have an effect on critical thinking skills. This can be interpreted that there are differences in students' critical thinking skills taught with PBL-assisted modules, picture media, and multimedia. Furthermore, the hypothesis 2 test decision in Table 4 is H_o is rejected or H_1 is accepted because the p-value of 0.002 < 0.05. We can conclude that learning styles have an effect on critical thinking skills. This means that there are differences in critical thinking skills between visual and auditory students. Finally, the decision of hypothesis 2 in Table 4 is H_o is rejected or H_1 accepted because the p-value of 0.000 < 0.05. It means that there is an interaction between the use of three different learning media with learning styles on critical thinking skills.

The results of the hypothesis 1 test can be illustrated in a comparison diagram of the percentage of students' frequency with the increased scores of pretest and posttest in each class presented in Figure 1.

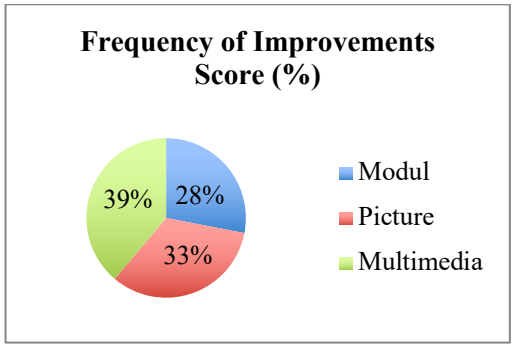

Figure 1 - Frequency of improvements scores.

To follow up on the results of the hypothesis 2 test, it is necessary to do a Least Significance Difference (LSD), which can be seen in Table 5.

Learning Media	Pretest	Posttest	Difference	Improve (%)
Modul with Visual	60,35	62,24	1,89	3,13
Modul with Auditori	35,61	41,48	5,87	16,48
Picture with Visual	61,63	68,07	6,44	10,45
Picture with Auditori	56,07	59,13	3,06	5,46
Multimedia with Visual	69,86	82,81	12,95	18,54
Multimedia with Auditori	60,63	67,75	7,12	11,74

Table 5 - The comparison of mean score of skills for all classes viewed from their learning styles.

Based on the comparative data on the average scores of students' critical thinking skills in Table 5, it can be concluded that learning styles affect students' critical thinking skills. This is because in every type of learning media, visual students always have higher critical thinking skills than auditory students. In addition, it was found that the use of multimedia in students with visual learning styles contributed the most in improving their critical thinking skills compared to the use of other learning media based on learning styles.

Furthermore, to follow up on the results of the hypothesis 3 test, a size effect test was conducted for the post hoc test, which is presented in Table 6.

Learning Media	Eta squared (n^2)	Effect size
Learning Media	0,199	Low
Learning Styles	0,114	Low
Learning Media*Gender	0,291	Medium

Table 6 - The calculation result of size effect test for Ancova test.

The effect size can be seen using eta squared and partial eta squared. This research uses partial eta squared as it presents a better effect size than eta squared (Field, 2009). Cohen (2003) divides the effect size into three categories of low (≤ 0.20), medium (≤ 0.50), and high (≤ 0.80). Based on Table 6, it can be concluded that learning media and learning styles have a weak effect on students' critical thinking skills. On the other hand, the interaction between the use of learning media and learning styles has a medium effect on students' critical thinking skills.

4. Discussion and Conclusions

Based on the research conducted, the decision of the first hypothesis test states that the null hypothesis is accepted, it can be concluded that there are different scores of critical thinking skills with different learning media. Based on the comparison diagram of the percentage of students with an increased pretest-posttest scores in each class, PBL-assisted multimedia provides the highest contribution to improve critical thinking skills by 39%, followed by the picture media by 33%, and modules by 28%.

Modules have the least contribution in improving critical thinking skills. This is due to the characteristics of elementary-school students who are at a concrete operational stage, which means their ability is to think about real objects or events (Lourenco, 2016). The module used in this research contains texts of learning materials without representation of information in the form of images, tables, or charts. This causes the module to be less able to concretize the learning material that will make the students difficult to understand abstract things more deeply. Therefore, Sejpal (2013) and Powell and colleagues (2015) state that modules are more suitable for students with more mature critical thinking skills, that is, is the student above elementary school with more developed thinking skills to understand the module without the help of representation of images, charts, diagrams, tables, etc.

The module will be more effective when combined with illustrations that can provide more explanation, extra information, interpret the broader context, and help students to remember more easily. This is supported by the research of Levie and Lentz (2015) showing that 98% of 155 students improve their understanding as a result of the effects of using illustrated modules. In this research, the picture media has a better contribution compared to modules in improving critical thinking skills. In his research, Dewan (2015) concludes that the use of picture media is better than the use of concrete words in learning. This is in line with the opinion of Shabiralyani (2015) that the use of visual media such as pictures makes the process of absorbing information in the learning process more effective. This is supported by the theory of Baker (2015) which states that the picture media makes it easier not only to recognize and process but also to remember and understand than words. Appiah (2006) also states that pictures are more effective in terms of telling something than modules or texts, in addition to that they can also be more attractive to people who need information than modules.

Multimedia provides the highest contribution compared to other learning media in improving critical thinking

skills. Molina and colleagues (2018) states that multimedia is a combination of various types of digital media such as texts, images, audio and video into the application or presentation of verbal and non-verbal information that is interactive for the audience. The use of multimedia in elementary-school learning is very important because the various features of multimedia can assist teachers in transferring learning materials in an interesting and fun way so that children can understand the topic of learning easily (Jastaniyah & Bach, 2017; Arkorful & Abaidoo, 2014).

The results of this research are supported by those of Hammadi's research (2010), which concludes that the class taught using multimedia is more critical than the control class taught without multimedia. Fajari (2020) also puts forward that students taught with PBL-based multimedia obtain higher scores of critical thinking skills than the students in the control class. Furthermore, Sari and Sugiyarto (2015) conclude that there is a positive effect of the use of problem-based multimedia on critical thinking skills since students who learn to use problem-based multimedia have the ability to deduce and express better assumptions compared to those in the control class. Neo and Neo (2001) also state that learning using problem-based multimedia is more effective for improving critical thinking skills than problem-based learning without learning media.

The decision of the second hypothesis test states that there are differences in critical thinking skills between visual and auditory students. Visual students have higher critical thinking-skill scores than auditory students. This research uses modules, picture media, and multimedia assisted for the treatment. All the three learning media can facilitate students with visual learning styles. Picture media and multimedia dominate the visual elements in their appearance, while the module is full of sentences. Meanwhile, auditory students are only facilitated by audio in multimedia. Thus, visual students benefit more from the three different learning media compared to auditory students. This is why, the average score of visual students' critical thinking skills is higher than that of auditory students' critical thinking skills. This is in line with the research of Gilakjani (2012) who concludes that multimedia is more suitable for visual students than auditory students, so that visual students have better academic performance. Facilitation of students with visual learning styles will have an impact on the optimal absorption of materials from the learning media compared to less-facilitated learning styles. The optimal absorption of learning contents is the basis for developing students' critical thinking skills. This is supported by the opinion of Gokalp (2013) that learning styles affect students' abilities in the learning process.

The result of this hypothesis test is consistent with the research hypothesis which states that visual students have higher critical thinking skills than auditory students. Suliman (2006) in his research also concludes that there is a correlation between learning styles and different levels of students' critical thinking skills (low, medium, and high). The results of this research are also supported by Nosratinia and Soleimannejad (2016) concluding that there is an effect of learning styles on students' critical thinking skills. However, the results of this research contradict those of Myers and Dyer's (2006) which show no difference in students' critical thinking skills based on their learning styles and those of Dilekli's (2017) which state that there are no significant differences between the variables of learning styles and critical thinking skills. Thus, we can imply that there is no effect of learning styles on students' critical thinking skills.

The third hypothesis test states that there is an interaction between the use of the three different learning media and learning styles on critical thinking skills. In other words, there are differences in students' critical thinking skills viewed from the experimental class and their learning styles. Based on the effect size test, PBL-based multimedia applied to visual students provides the highest contribution in improving critical thinking skills when compared to the effect of other learning media and learning styles. If you look at the average scores of students' critical thinking skills, there are different scores on visual students and auditory students. In each experimental class, visual students always have higher scores compared to auditory students. This is supported by the research results of Smith and Woody (2000) that multimedia is very beneficial for students with high visual orientation. Lu and Yang (2018) also conclude that students with visual learning styles get better learning achievements than those with other styles that are equally taught by multimedia.

Meanwhile, the use of modules in visual students contributes the lowest to improve critical thinking skills. The use of modules in this research is considered less effective for visual students because they are not motivated to learn just by only seeing texts without information representations such as tables, charts, or other informative images. Students who are not motivated in learning will not try to achieve learning goals to the maximum. This is supported by the opinion of Souriyavongsa and colleagues (2013) about the factors that cause the low learning activities of students i.e. students' interest in the presentation of learning materials.

The results of this research are backed by the research of Wanpen (2013) and Rahadian and Budiningsih (2017) who conclude that there is an interaction between learning media and learning styles in influencing the ability to understand learning materials that has an impact on the students' achievements. Smith and Woody (2000) and Surjono (2015) also conclude that there is an interaction between learning media and learning styles on the achievements of student learning performance. Soylu and Akkoyunlu (2002) and Fan and Xiao (2015) in their research also conclude that there is an interaction

between learning media and learning styles on students' learning outcomes.

Based on the results of the research and discussion, we can conclude that the three PBL-assisted learning media have an effect on students' critical thinking skills. Students with multimedia have the highest critical thinking skills. Furthermore, learning styles have an effect on students' critical thinking skills. Visual students have higher critical thinking skills compared to auditory students. Based on the results of the effect size test, there is an interaction between the three PBL-assisted media and the learning styles on students' critical thinking skills. PBL-assisted multimedia contributes the highest in improving students' critical thinking skills.

Based on the above conclusions, there are some recommendations for teachers to apply PBL-assisted multimedia to the learning process in elementary schools to train students' critical thinking skills. This is because PBL-based multimedia provides the highest contribution in improving critical thinking skills (especially for visual students) when compared to the effect of other learning media and learning styles. In addition, the teacher has to adjust the making of multimedia to all types of students' learning styles such as the addition of audio elements so that auditory students are properly facilitated. On the other hand, the use of modules that are too intense in learning is very ineffective for elementary school students. Critical thinking skills must be trained from an early age because these skills are the 21st century life skills that are the most important for students' lives in the future. Furthermore, students' critical thinking skills must be routinely trained through meaningful learning and thinking habits as early as possible.

This research is limited to the elementary-school level. It would be far more interesting to do the research in the middle or high school students who have more mature thinking skills. In addition, future researchers can conduct similar researches by measuring other 21st century skills such as creative-thinking skills, problem-solving skills, communication skills and so on.

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