



Enhancing Critical Thinking using LCDS-Based Interactive Electronic School Book in Physics

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Received: May 11, 2019

Accepted: June 29, 2019

Published: June 30, 2019

Abstract: This study aims to describe the effectiveness of interactive BSE utilization as a supplement for blackbody radiation learning in improving student's critical thinking skills. The methods used were qualitative and quantitative with purposive sampling technique. We applied scientific based learning, where the experimental class used BSE interactive, while the control one used BSE non interactive. The results indicated that the learning used BSE interactive significantly and effectively could improve student's critical thinking skills at the 95% confidence level. Furthermore, there were significant differences in the critical thinking skills improvement between the experimental and control classes at the 95% confidence level with an N-gain value of 0.64 for the class that used interactive BSE and 0.53 for the class that used non-interactive BSE. The effect size value of interactive BSE utilization compared to non-interactive BSE was categorized in a high criteria with a Cohen's value of 1.78. These results were also supported by students' positive responses to interactive BSE utilization.

Keywords: LCDS, critical thinking, blackbody radiation, BSE

DOI: <http://dx.doi.org/10.23960/jpf.v7.n1.201902>

INTRODUCTION

The implementation of the 2013 curriculum requires a learning paradigm shift from conventional learning that is only done in the classroom, to learning that activates students to use a variety of learning resources that can be obtained outside the classroom. Scientific learning used in the 2013 curriculum includes five learning activities, namely: observing, asking questions, conducting experiments or seeking information, doing reasoning or associations to process information and develop networks or communicate the results of investigations. The characteristics of learning are the key to producing students who are creative and innovative (Sani, 2014).

The 2013 curriculum also applies the scientific approach (scientific approach) in various subjects. The scientific approach consists of observing, asking, exploring, communicating, and associating. These activities are effort to encourage students to be better at observing, asking, reasoning, and communicating what students get after receiving learning material. In the scientific approach, the physics teacher must be more active in fostering the creativity of students and giving more ability to improve the ability to think creatively, innovatively, and critically.

Black matter-radiation material that is classified as abstract is very difficult for students to understand. Therefore, the abstract nature of black matter-radiation material needs to be made more real with the help of multimedia. The expectation of interactive multimedia in physics learning on black matter-radiation material is expected to be effective to improve students' thinking skills, especially to improve critical thinking skills. Kurniawan et al. (2015) also said that learning physics using interactive media based on phenomena in everyday life will be more interesting and effective.

Preliminary research showed that learning media used in the learning process in the twelfth graders were generally in the form of teacher-made student worksheets without any experiments. This was due to the limited time in the learning process, where the students had to complete the material and also prepare the national examination, so that students did not understand the concepts of physics well, especially in the material of black body radiation which was classified as abstract, and the learning process applied by teachers tend to be at a low level of thinking ability. Related to these problems, it was certainly very important for us to find alternative solutions so that students were able to comprehend abstract material especially in the black matter radiation learning. If not, then these students would be weak in scientific reasoning and conceptual understanding, which certainly had an impact on their low level of thinking skills (Dowd et al., 2018). In fact, higher order thinking skills were demands of the 21st century. Therefore, we offered the use of LCDS-based interactive e-book as a solution to these problems. Research on the development of LCDS-based e-books had been widely conducted (Ayuningtias et al., 2018; Suyatna et al., 2018; Hasan et al., 2018). However, implementing LCDS usage was still in the context of limited trials. So, in this study we were more oriented towards a wider sample to test the effectiveness of using LCDS-based interactive BSE in improving students' critical thinking skills.

The study of Hayati et al. (2015) showed that *Buku Sekolah Elektronik* (BSE) or Electronic School Books are one of the teaching books that are now widely used in various schools in Indonesia. The copyright has been purchased by the Ministry of Education and Culture, which includes textbooks from various subjects ranging from basic to advanced levels in digital form and can be printed. Some of the advantages that make BSE more attractive to teachers than conventional textbooks include BSE easily obtained by downloading the official website of the Ministry of Education, conformity

of content with the curriculum, not knowing expiration, easy to understand language, and passing the assessment of the National Education Standards Agency as a textbook that is suitable for use in learning. Non-interactive BSE and interactive BSE have similarities in terms of price and practicality. BSE prices are cheap and practical to carry everywhere. Wardani et al. (2012) also stated that BSE interactively has a price that is relatively cheaper, practical, and pleasant to read.

Non-interactive BSE and interactive BSE also have differences in terms of content and how to use it. The contents of non-interactive BSE only consist of text and images, while BSE is interactive not only text and images, but accompanied by videos, animation, simulations, and interactive matter exercises. An interactive E-book created by combining verbal and visual explanations in the form of text, images, simulations, animations and videos as well as practice questions to support the learning of quantum physics so that they can explain the abstract concepts easy (Hidayat et al., 2017). How to use non-interactive BSE can be via android or laptop without using an application, while using the interactive BSE must use the application to operate it, one of which is Mozilla firefox type 35 or 37.

Based on those explanations, the application of interactive electronic books had the potential to improve students' critical thinking skills, especially for some abstract Physics material. Besides that, it could also be an alternative solution to the problems previously described. So, the research that we carried out aims to describe the effectiveness of interactive BSE utilization as a supplement for blackbody radiation learning in improving student's critical thinking skills.

METHOD

The study was conducted for two weeks. It started on January 16, 2019, until January 31, 2019, in SMAN 1 Natar.

Research Design & Procedure

The research design applied in this study was quasi-experiment-design and using the type of experiment the non-equivalent pretest-posttest control group design. The diagram of this research design is illustrated in Figure 1.

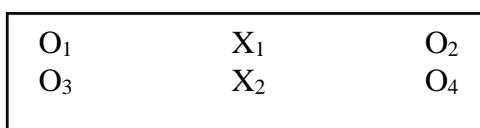


Figure 1. Research Design

The pretest of the O_1 experimental class and the pretest of the O_3 control class can be used as a basis for changes. Giving the posttest of the O_2 and Posttest experimental classes of the O_4 experimental class at the end of the activity will be able to show how far the consequences appear after being given treatment. The treatment given to the experimental class is the interactive BSE implementation (X_1), while the control class is treated using non-interactive BSE (X_2).

Population and Sample

We used random sampling techniques. The sample of this research were all IPA 1 and IPA 3 twelfth graders of SMAN 1 Natar in South Lampung Regency 2018/2019 academic year, with each class consisting of 35 students. There were two classes selected as samples, then one class was determined as an experimental class using interactive BSE and one class as a control class using non-interactive BSE. In the learning, the experiment class was done by operating the BSE interactively on a laptop, because BSE is integrated with the media. Whereas in the learning control class carried out using non-interactive BSE and videos, animations, simulations displayed on the screen, because non-interactive BSE is not integrated with the media so that its use is separated from the media.

Data Collection and Instrument

Research data obtained from pretest-posttest results of student's critical thinking data and student responses to the use of interactive BSE. The instruments we used for data collection were a critical thinking test instrument and a questionnaire of student responses regarding the use of interactive BSE. Before the test instrument was used in the sample, the instrument was firstly tested using the validity and reliability test. The test technique used was the Pearson Product Moment Correlation technique. Instrument was reliable if the interpretation criteria for the reliability index was >0.6 . The criteria for interpreting index validity that we used was according to Arikunto (2016) were shown in Table 1.

Table 1. Interpretation of Validity

Correlation Number	Criteria
0.00 – 0.20	Relationship is very low
0.21 – 0.40	Low relationship
0.41 – 0.60	Enough relationship
0.61 – 0.80	High relationship
0.81 – 1.00	Relationship is very high

Data Analysis

Overall, the data analysis techniques we used were descriptive and inferential quantitative analysis techniques. For the quantitative data, we analyze the data using normality test, homogeneity test, parametric test, and N-gain test. The normality test in the study used the Kolmogorov-Smirnov test. Then the homogeneity test was conducted to find out whether the sample data had a homogeneous variance or not.

The hypothesis in this study were analyzed using two types of inferential statistical tests, namely the paired sample t-test and the independent sample t-test. The basis of decision making in both hypothesis tests are: (1) If the significance value is ≤ 0.05 , then H_0 is rejected (2) If the significance value is > 0.05 , then H_0 is accepted.

Then N-gain analysis was used to determine the effectiveness of the increase in students' pretest and posttest scores. Then the N-gain interpretation criteria could be seen in Table 2. The effectiveness of interactive BSE application on critical thinking skills was also examined by the effect size analysis.

Table 2. N-gain Interpretation Criteria

N-gain	Criteria
$g > 0.7$	High
$0.3 \leq g \leq 0.7$	Medium
$g < 0.3$	Low

The effect size of 0.20 means that it has a small effect, 0.50 has a moderate effect, 0.80 has a large effect. In detail, the category of effect size values can be seen in Table 3.

Table 3. Value size effect category

Effect size	Criteria
$d < 0.2$	Low
$0.2 < d < 0.8$	Medium
$d > 0.8$	High

The usefulness of interactive BSE was obtained from student response questionnaires. Data obtained through questionnaires in the form of qualitative data, then converted into quantitative data to find out how high students respond to the use of interactive BSE. Quantitative data was obtained by giving the scores of each Likert scale category for favorable items, they were 4 for strongly agree, 3 for agree, 2 for disagree, and 1 for strongly disagree.

RESULT AND DISCUSSION

The effectiveness of the use of interactive BSE that we described was based on four data findings, they were from the significance of the increase in the posttest pretest score after the application of interactive BSE supported by the N-gain test, the significance of the difference between the experimental class (using interactive BSE) and the experimental class (using non-interactive BSE/static book), and student responses to the use of interactive BSE.

First, we analyze the normality and homogeneity of data. We tested the normality of N-gain data for each pretest-posttest. Based on the analysis results, all data were normally distributed with 0.540 significance values for the experimental class and 0.213 for the control class. Then, we continued to homogeneity test. The Levene test showed that all data were homogeneous with significance value of 0.697, and Levene statistic value of 0.153 which means all data had the same variant.

Then, we conducted inferential statistic tests using independent sample t-test for the experimental and control classes to examine the difference of students' critical thinking skills improvement in both classes. The independent sample t-test results showed the significance value < 0.05 , it could be indicated that H_0 was rejected and H_1 was accepted so that means there was a significant difference in the average N-gain between the experimental class and the control class.

Furthermore, the improvement of student's critical thinking skills was examined using paired sample t-test based on pretest-posttest results in experimental and control classes. The paired sample t-test results for experimental class showed the significance value < 0.05 , which means the BSE interactive could significantly improve student's critical thinking skills. While, the significance value of the posttest pretest score for the control class showed a number of more than 0.05, which means there was no significant increase after the application of the static book. These results were supported by N-gain analysis to see the effectiveness of interactive BSE application. The N-gain analysis results was presented in Table 4.

Table 4. N-gain Analysis Results of Student's Critical Thinking Skills

Parameter	Experimental Class	Control Class
Mean Pretest	46.23	43.44
Mean Posttest	80.07	73.07
Average N-gain	0.64	0.53
Category	Medium	Medium

Based on Table 4, an increase of student's critical thinking skills in the experimental class using interactive BSE was greater than the control class with non-interactive BSE used in schools. Through the calculation of the average N-gain, the control class did show an increase in the value of the students' pretest posttest in the medium category. However, the increase was not statistically significant. The distribution of N-gain values from the entire sample could be seen in detail in Figure 2.

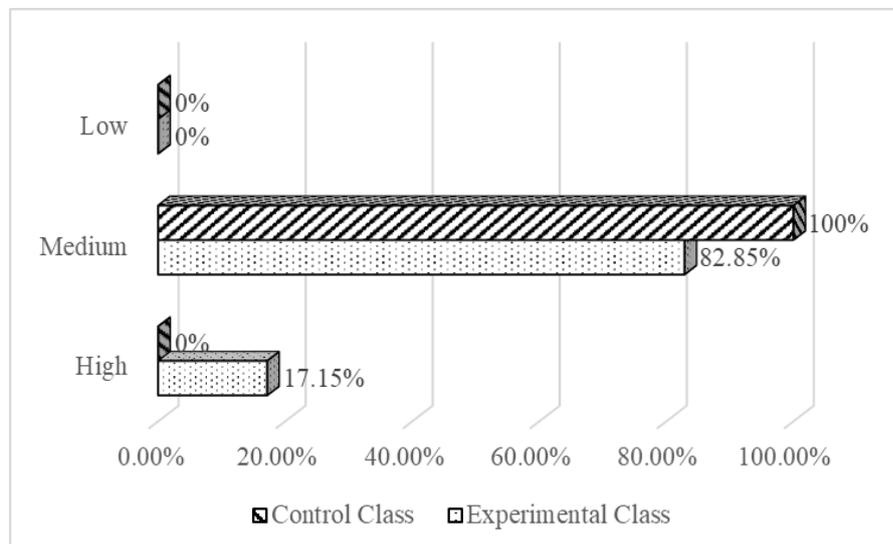


Figure 2. The Distribution of N-gain Values

Figure 2 showed that interactive BSE gave a better influence on student's critical thinking skills enhancement. Even though static books do have a positive impact on improving students' critical thinking skills, increasing skills was only at the medium level. Meanwhile, interactive BSE had a better influence by showing that the increase could reach a high level.

The findings for experimental class was strengthened by the effect size analysis result. The calculation of the effect size produced Cohen's value (d) of 1.78 and the effect size of r was 0.6. The provisions of the table effect size if d was more than 0.8, it could be categorized as large, because d obtained in this data was 1.78, it was categorized as a large effect size effect. The effectiveness of learning using a method that has been applied to learning was very effective because Cohen's obtained in the high-effect effect. From the results of the student response questionnaire, there was no one respondent who answered strongly disagree with the use of interactive BSE. There were only five students who answer disagree and other students on average answer agree and strongly agree. These findings means almost all students gave positive responses to interactive BSE implementation.

Based on the paired sample t -test, it could be concluded that there was a significant improvement in the mean value of student's critical thinking skills in the experimental class. The mean value of student's critical thinking skills before being applied to learning by using interactive BSE was only 46.23, then after applied learning using interactive BSE, the mean value increased to 80.07. This happened because the contents of the BSE were interactive not only text and images, but were integrated with the media, namely, there are videos, animations, simulations, and critical thinking tests. So, those facilities helped students answer questions from the various level of analysis. The video was displayed on the interactive BSE regarding the phenomenon of black matter-radiation and the laws of black matter-radiation that are related to everyday life, so students could easily understand the relation between black matter-radiation and everyday life (Margoniner et al., 2019; Hockicko et al., 2015; Klein et al., 2015). Not only were the videos displayed there were also simulations and animations about black matter-radiation and black matter-radiation laws. The simulations in the interactive BSE displayed various forms of virtual manipulatives related to the physics phenomena, this made student's activeness increase because simulations could be done repeatedly easily, so students could understand the contents of the simulation carefully (Olympiou & Zacharia, 2018). The increase in experimental class was also due to students not only hearing the teacher's explanation but could play an active role with the learning tools and strategy and used their understanding of concepts learned in real life, thus influencing students' higher order thinking skills (Nurulsari et al., 2017), especially critical thinking skills (Stupple et al., 2017; Živkovi, 2016). In the interactive BSE, there was also a critical thinking test. The critical thinking test in the interactive BSE had an answer, so students could learn it independently. N-gain average of the experimental class was greater than the control class, this was due to the learning in the experimental class using interesting BSE and make students curiosity in high black matter-radiation material, thus guided students play a role active in learning. This is because, in the BSE interactive many animations and images, videos that were displayed are directly related to daily life, simulations on interactive BSE could be done repeatedly, and there were questions of critical thinking. Whereas the non-interactive BSE only consists of text and images, for videos, animations, simulations, and critical thinking texts displayed separately from BSE.

The way to use BSE interactively was also easy and there were instructions for use in it, so students have no trouble when using interactive BSE in the learning process. Using an interactive BSE could also make the abstract properties of black body radiation diminish because the videos displayed were based on everyday life. These results were supported by the results of a study by Hidayat et al. (2017), regarding

interactive e-books created by combining verbal and visual explanations in the form of text, images, simulations, animations and videos, and practice exercises to support the learning of quantum physics so that they can explain abstract concept easily. Other support obtained from Lestari et al. (2012), according to their research found that there was an increase in student learning outcomes using interactive multimedia viewed from the average pre-test results and the post-test average. The large effect size result in the experimental class using interactive BSE occurred because the contents of the interactive BSE were integrated with the media with learning being a unity between media and text, not like non-interactive BSE which only consists of text and images only, and the use of separate media with text. Based on the analysis results, it could be indicated that the interactive BSE was very effective to be used in the physics learning of black matter-radiation material, this was evidenced from the value of Cohen d at 1.78 with effect size $d > 0.8$ in the high category.

The descriptive analysis results based on the results of filling out questionnaires by students showed positive responses with the percentage of 85.7% of all indicators observed, and 14.3% respond negatively. Judging from each statement, out of the 12 statements there were three statements that received a "disagree" answer with a percentage of 14.3%, which meant that there were 5 students who answered disagree. The statement was "I believe the results of my physics learning increased by learning to use interactive BSE", "With my interactive BSE I analyzed experimental data easily" and "My material understanding improved with learning to use BSE interactively". Based on the three statements, each statement indicated that students were still lacking in confidence and we're sure to learn to use interactive BSE. This is due to the lack of motivation to study physics. This is also supported by the opinion of physics teacher who said that "children are less learning motivation". He also added that "it is very necessary to give more attention to students, especially those whose learning motivation is still very low". Students stated that they felt happy during the learning process to use interactive BSE because at BSE there were many images and animations, and the learning process was very fun and not boring. Students felt excited because in learning students could play an active role without hesitation. They stated that they could operate the interactive BSE on the laptop easily. Students feel confident when going to do the test, this was because in the interactive BSE there were critical thinking tests that make students better understand the material.

Students were careful in carrying out simulations and the simulations in interactive BSE could be repeated easily. Students could easily understand the material using an interactive BSE because the appearance of the video in the form of a phenomenon of black matter-radiation and the laws of black body radiation were directly related to everyday life. Not only was the explanation on the interactive BSE also coherent so that students could easily understand the material. Students had a sense of wanting to master learning when using interactive BSE because the videos and animations displayed on the BSE interact interactively with everyday life, making students curious and want to master the material.

Based on the explanation above, it can be indicated that the interactive BSE was very useful and effective to be applied in physics learning, especially in black matter-radiation material. This result was in line with the study of Lestari et al. (2012). They stated that learning to use interactive multimedia makes students enthusiastic and the curiosity of students increases, and able to solve problems with their own ideas. The same idea was stated by Wahyu (2017), his study showed that students feel easy, feel interested, and feel happy when participating in learning activities by using BSE. As well as being supported by the research results of

Wicaksono et al. (2013). According to his research interactive multimedia is very interesting, very easy to use, and very useful and declared effective to be used as a learning media.

CONCLUSION

Learning using interactive BSE could significantly improved student's critical thinking skills at the 95% level of trust. There was a significant improvement difference of student's critical thinking skills in the class that used interactive BSE compared to those using non-interactive BSE with N-gain value of 0.64 for the experimental class and 0.53 for the control one. Effect of interactive BSE utilization size compared to non-interactive BSE categorized as high with Cohen d score of 1.78. Students also gave positive responses to interactive BSE utilization with a percentage of 85.7%. The overall results lead to one conclusion that the use of interactive BSE in learning Physics with abstract material was very effective in improving students' critical thinking skills.

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