The Effectiveness of Interactive E-Book for Self-Study and Increasing Students' Critical Thinking Skills in Electromagnetic Radiation Topic

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Abstract. This research aims to develop interactive e-book on electromagnetic radiation topic, which can be used for self-study, and to increase students critical thinking skill. The methodology in this research is based on ADDIE model research and development (R&D) design which consist of *analysis, design, development, implementation, and evaluation.* The data resource was the students and teachers of XII grade of senior high schools in Lampung Province. The instrument used were questionnaire and test instrument. Data analysis technique was conducted descriptively with interval using *n-gain*, *independent t-test*, and *paired t-test.* The research showed that interactive e-book on electromagnetic radiation was effective for self-study and to increase critical thinking skill of the students significantly at a confidence level of 95%, with *N-gain*ing experimental group <g> = 0.76 which was higher than in control group <g> = 0.55. Therefore, it can be concluded that the product which was developed namely interactive e-book on electromagnetic radiation is effective for self-study and to increase students' critical thinking skill.

1. Introduction

Ministry of National Education Regulation No. 65 of 2013 on Primary and Secondary Process Standard implies the need for an interactive, inspirational, fun, and motivating process for active participation, guided by the principles of a scientific approach. The effort in applying scientific approach in the learning process is the characteristic of2013 curriculum. Science learning has an important role in preparing students to be able to think critically, creatively, logically and initiative [1]. Physics is one of science branches which is closely related to the phenomena that occur in the surrounding natural environment. Not all physical phenomena can be observed directly, one of which is on electromagnetic radiation material. Electromagnetic radiation material is difficult to practice directly, because, to practice on such material requires sophisticated tools which are not available in schools [2]. Physics is a unique and interesting science because the subject of physics is difficult to teach and difficult to understand [3]. In the learning process, 83% of students, sometimes, experience difficulties in learning Physics materials, and 29% of students says that the teaching methods used by teachers are less appropriate.

Another difficulty is to present scientific learning in studying electromagnetic radiation, due to the limitations of practicum and time. The time for discussing this material is limited because this material is in the XII grade of even semester, where the school uses time for preparation of National Exam (UN). With the limited time of study owned by XII grade students in the even semester, not all XII grade material in the even semester is completely learned. Although it is thoroughly learned, the teacher only explains the material briefly and the teacher only gives the exercise questions. Problems given by the

teacher are limited to the choice of plural choice, which only requires students to use related formulas, without making students think critically [2].

Critical thinking in cognitive psychology as a problem-solving process in the context of self-interaction, for example, how one responds to a situation by analyzing facts, generating and organizing ideas, defending opinions, comparing, evaluating arguments, and finally solving the problems [4]. The very dominant thinking skill needed in the 21st century is critical thinking skill [5-6]. Critical thinking is an educational goal, because, through this skill, learners move away from learning to think about what they learn, and not what others think [7]. Students who are able to think critically can solve problems effectively [8]. Based on the demands of the current learning curriculum, students conceptual understanding can be increased through the development of students' critical thinking skill.

Physics learning can be used to train students to think critically. It is based on preliminary research conducted by researchers towards teachers and students of XII grade of senior high school in Lampung province. The results of the questionnaire obtained 97% of media often used in learning, in the form of printed books from schools that have not yet interactive, and have not fostered critical thinking of students, 70% of students stated that the physics questions provided by teachers have not made students think critically. 64% of students stated that the physics book should be useful in the learning process that is to facilitate the study of physics, and 55% of students stated that the physics book used in the lesson has not to meet satisfactorily. In physics learning, students expect that teachers have to use interactive electronic books that can be used independently, which can facilitate the study of physics that contains instructions on the use, instructional instructions, learning objectives, learning materials, problem and discussion samples, illustration video, animation, summaries, and interactive quizzes supported with feedback for exam exercises and preparing for admission to universities [2].

In the learning process, besides using printed books from schools, there are students who seek other learning resources, one of them is by using interactive electronic books (IEB). An electronic book is an electronic form of a book with features which are similar to a printed book, including pages that can help readers like word pronunciation, text highlight, and hypermedia such as video, animation, and sound [9]. IEB can be used as a learning resource. Electronic books or more often known as e-books are books that are programmed into the computer. The e-book has evolved into an interactive e-book namely a book in a digital format in which there is a mix of text, images, sounds, and videos where a computer or other supporting media are needed to use this. An interactive e-book can serve as a learning resource for students to increase student motivation and provide better learning outcomes [10].

Innovative physics learning, which can facilitate students in observing the phenomena that are difficult to observe directly, one of them is using IEB which shows video illustrations, pictures, sounds, and text. The media can be arranged so that learners can independently learn the material and gain more knowledge so that students are able to learn independently. The key to self-study is the "initiative" or "proactive" attitude of a person to manage his learning [11].

The purpose of this research is to develop IEB on electromagnetic radiation material that can be used for self-learning and to increase students' critical thinking skill. Until now, such books for electromagnetic radiation material have not existed, because the material of electromagnetic radiation is very abstract [12], so to overcome this problem IEB on electromagnetic radiation material is required that can be used for self-study and to increasing students' critical thinking skill.

2. Methods and Materials

The method in this research was based on research and development (R&D) design, which uses the ADDIE development model, consisting of analysis, design, development, implementation, and evaluation. The first stage was the analysis. Analysis of the requirements was conducted at two senior high schools in East Lampung District, involving two Physics teachers and 87 students. The data of IEB requirements were collected using questionnaires. Questionnaire on requirement analysis was conducted to obtain information about real conditions in the learning process in school. The data were analyzed quantitatively and descriptively. After performing data analysis, then the design of IEB was conducted starting from designing learning device to design the developed product. Furthermore, IEB development

which contains activities of product design realization then proceeded with validation stage design expert. The data analysis performed on the basis of expert test instrument was carried out by giving the score of 4, 3, 2, and 1 with the answer choices according to the question content: "Very Important (SP)", "Important (P)", "Not Important TP) ", and" Very Unimportant (STP) ". The average of the assessment results was then searched [13] by using the formula:

$$\text{Score Average} = \frac{Total\ Score}{The\ Total\ of\ Experts}$$

Having obtained the average, then it was converted to the assessment statement. The conversion of the score into an assessment statement was presented in **Table 1.** Field trial stage used the interactive electronic book on electromagnetic radiation material in learning activities. The data collected derived from a questionnaire of practicality consisting of student responses and IEB implementation, as well as special tests. Questionnaires were used to determine the effectiveness of IEB and students' responses to the products that have been developed. While special tests in the form of pretest and posttest were used to determine the effectiveness of the product.

Analysis of *pretest* and *posttest results* to test product effectiveness is used N-Gain score. The N-Gain score is derived from the following formula: -Gain score was used for the analysis on *pretest* and *posttest* results to test product effectiveness. N-Gain score [14] was obtained from the following formula:

$$(g) = normalized\ gain = \frac{post\ test - pre\ test}{skor\ maksimum - pre\ test}$$

The result of gain calculation was then interpreted by means of normalized gain using classification, namely: $(g) \geq 0{,}70$ with "High" classification; $0{,}30 \leq (g) > 0{,}70$ with "Medium" classification; and $(g) < 0{,}30$ with "Low" classification. Knowing the difference in mean values between the experimental group, which use IEB and control group which do not use IEB, can be performed using *independent sample t-test*. Basic decision-making was based on probability value, where if sig> 0,05 then H_0 is accepted. However, if sig <0.05 then H_0 is rejected. Knowing an increase between *pretest* and *posttest*, *paired sample t-test* can also be used. Basic decision-making was based on probability value, where if sig> 0,05 then H_0 is accepted. However, if sig <0.05 then H_0 is rejected.

Table 1 Criteria Score

Score	Average Score Score	Classification
4	3.26- 4.00	Very Good
3	2.51 - 3.25	Good
2	1.76- 2.50	Less Good
1	1.01 - 1.75	Not Good

3. Results and Discussion

The result of this research and development is the interactive electronic book on electromagnetic radiation based on LCDS for self-study and to increasing students' critical thinking skill. The results of each stage of the development procedure are treated as follows: the analysis stage is the activity of collecting data of teachers and student requirements on interactive electronic books on electromagnetic radiation material. The data collection activities were conducted through questionnaire technique aimed at XII grade teachers and students in two senior high schools in East Lampung District. The analysis on requirements was conducted at two senior high schools in East Lampung District involving two Physics teachers and 87 students. Based on the requirement analysis, it is known that 83% of students have difficulty in learning physics material. The facilities provided by schools to support the process of physics learning include experimental tools that exist in the physics laboratory, but the tools are

incomplete, and only a little number of parts works well. Despite the availability of LCD, wifi network in schools, and physics books in the school library, students still found difficulties in learning physics. Another difficulty in learning electromagnetic radiation material is the limited time in discussing this material because originally this material is for XII grade students in even semester, where the school uses the time for preparation of the National Exam (UN). The limited time of study owned by the students of XII grade in the even semester causes some XII grade materials in the even semester not completely learned.

Design stage, this activity is a systematic process that starts with designing learning tools: setting learning goals; designing scenarios or teaching and learning activities; designing learning materials and learning result evaluation tools; and designing interactive electronic book products developed, Basic Competence of 3.6 evaluates its thinking about electromagnetic radiation, its use in technology, and its impact on life.

Development Stage. This stage contains the realization activities of product design that is ready to be implemented. The result of product development carried out at this stage is in the form of prototype I. The interactive electronic book format that will be developed is: the opening chapters that contain the front coverage instructions, study instructions, and content standards (**Figure 1**) and (**Figure 2**).

Figure 1 The cover view interactive electronic book on electromagnetic radiation

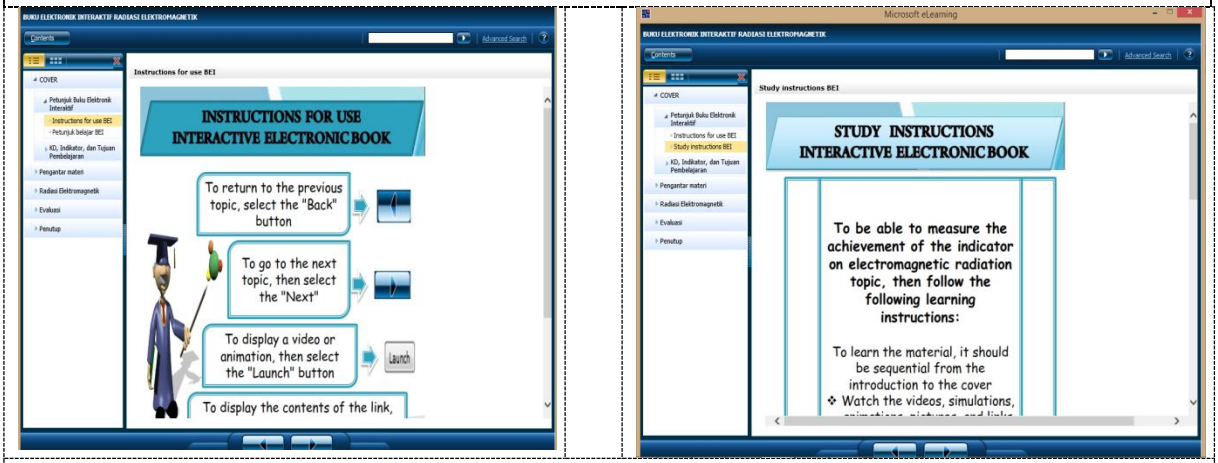

Figure 2. Display usage instruction interactive electronic book on electromagnetic radiation

Learning activities consist of four sub-sections to be studied: material introductions, electromagnetic wave concepts, electromagnetic spectrum, electromagnetic radiation utilization, and electromagnetic radiation hazards, as well as the summary. The evaluation includes a plural selection with feedback consisting of 10 items of questions related to the predetermined learning content, with details of the indicator of critical thinking skill. Cover contains a bibliography and author profile. The initial product produced is tested for its feasibility, which includes a validity test consisting of the content/material expert test, construct/design expert test, and a one-on-one test. The expert validation test was conducted by three expert lecturers and two expert practitioners. The test results of the expert validation of the products that have been developed can be seen in **Table 2.**

Implementation stage. This stage is conducted at one senior high school in East Lampung Regency, which consists of 24 students. In the Implementation stage, a practicality test consisting of user response and instructional execution on the interactive electronic book on electromagnetic radiation material as well as effectiveness test is carried out. Users' responses can be identified by providing questionnaires containing 34 questions each, addressed to experimental group students who have used the product in the learning activity. The implementation of learning can be known by the way teachers observe the practitioners and by asking teachers to fill out a questionnaire containing 18 questions. The results of users' responses to products that have been developed can be seen in **Table 3**. And the results of the implementation of products that have been developed can be seen in **Table 4**. The average score of n-gain test results in the experimental and control group can be seen in **Table 5**.

Table 2 Expert test results

Validator	Type Test	Value	Qualitative Statement
Expert 1	Content validity	3.1	Good
	Construct Validity	3.1	Good
Expert 2	Content validity	3.5	Very Good
	Construct Validity	3.5	Very Good
Expert 3	Content validity	3.3	Very Good
	Construct Validity	3.1	Good
Expert 4	Content validity	3.5	Very Good
	Construct Validity	3.6	Very Good
Expert 5	Content validity	3.4	Very Good
	Construct Validity	3.6	Very Good

Table 3 Results of student responses to products

Aspects tested	Percentage Score	Criteria
Aspects Effective	3.5	Very High
Interactive Aspect	3.5	Very High
Aspects Efficient	3.6	Very High
Aspect Ease	3.4	Very High
Aspect Self-study	3.5	Very High
Percentage of End Score Student Response Test	3.5	Very High

Table 4 The results of the learning implementation test of the product

Aspects tested	Percentage Score	Criteria
Implementation of interactive electronic books for self-study	3.6	Very Good
Social System	2.6	Good
Reaction Principle (Teacher Behavior)	3.8	Excellent
Percentage of End Test Score Test	3.3	Very Good

Table 5 Mean of the n-gain test result

	Highest	Value Lowest Score	Pre Test	Post Test	N-Gain
Experiment Class	92	60	13.67	79.67	0.76
Control Class	80	40	11.92	61.33	0,55

The increasing mean of critical thinking skill based on the indicators in the experimental group and control group can be seen in **Table 6**. It is known that all the critical thinking skill indicators in the control group are in the 'moderate' category, while the experimental group is in the 'high' category.

Table 6 The calculation result of the increase of critical thinking indicator

No	Critical Thinking Indicator	Classroom Experiment				Class Control			
		Pretest	Posttest	N-gain	P value	Pretest	Posttest	N-gain	P value
1	Interpretation	11,67	78,4	0,76	0,000 *	11,17	61,69	0 , 57	0,000 *
2	Elementarycl arification	13,33	76,67	0,73	0,000 *	12	56,67	0,51	0,000 *
3	Advanced clarification	14,17	81,67	0,79	0,000 *	11,67	62,50	0,57	0,000 *
4	Identify	12,50	76,67	0,73	0,000 *	9,17	40,83	0,34	0,000 *
5	Exploration	12,5	83,33	0,81	0,000 *	11,67	51,67	0.45	0,000 *
6	Analysis	14,17	73,33	0,70	0,000 *	13,33	61,67	0,57	0,000 *
7	Evaluation	17.50	85,00	0,82	0,000 *	15,00	70,83	0,66	0,000 *

*) significantly different at the 5% level

The result of statistical hypothesis test using Independent Sample T-Test, it is found that the Sig value of0.000 <0,005; it can be concluded that there is a difference between the mean of posttest value in the experimental group and the mean of posttest score in the control group, or significantly, the mean of posttest of the experimental group which use IEB on electromagnetic radiation which has been developed is higher than the mean of posttest score of control group test which does not use IEB on electromagnetic radiation of development results. The results of statistical hypothesis test using paired sample t-test obtained Sig value of 0.000 <0,05; it can be concluded that posttest value after using IEB on electromagnetic radiation which has been developed is significantly higher than the pretest value before using the developed product.

Based on the results of the research, it is obtained that the final average score of the five validators for the content expert test is 3.3 which means it is very high. An interactive e-book is very suitable for physics learning because it can provide images and text so that it can clarify the theory [15]. An interactive e-book has several important roles, one of which is increasing student activeness [16]. Construction expert test obtained the final average score of the five validators of 3.4 which means that it is very high. It shows that the interactive electronic book on electromagnetic radiation as the development results is feasible in terms of content and construction. A learning which is able to combine text, images, audio, music, animated images or video in one entity which supports each other can increase student motivation during teaching and learning process until the objectives of maximal self-study are obtained [17]. Interactive video increasings learning interactivity, so that it potentially increasing the effectiveness, and create consistent student learning motivation [18]. Students more easily understand what is learned by viewing the video material. Through the video, things or real events related to the material being studied can be displayed so that students more easily understand the material [19]. One of the features that make learning interesting for learners is the real concept which makes learning more meaningful when the latest technologies are used, unlike traditional methods [20]. There

are many studies that widely apply animation, video, simulation, and computer aids in science education [21]. The results of validation test of content and construct experts show that this interactive electronic book is made by combining explanations verbally and visually, in the form of text, images, tables, animation, and video, as well as interactive questions, to support the learning of electromagnetic radiation so that it can explain the abstract easily and can be used independently.

The results of the students' responses indicate that LCDS based interactive electronic book on electromagnetic radiation books are practically used in the learning process. Interactive activities can provide an exciting and enjoyable learning experience. Through interactive books, students can learn in a fun way, and acquire new skills [22]. Exercise activities that exist on the e-book encourage students to be responsible and discipline by answering it on the link that has been provided [23]. Electronic School Book demonstrates physics phenomena that increase curiosity, and it can be used independently by students, and reduce their difficulty in understanding abstract physics materials [24].

Based on the results of product implementation test that has been developed, it is obtained the final score of 3.3; which demonstrates that IEB on electromagnetic radiation of development results is very good to be used for self-learning. A very high percentage of product implementation is based on the reason that easy operation of interactive e-book enables students to learn independently using interactive electronic books. Students are able to observe the phenomena provided in an interactive electronic book. Students are able to independently analyze data related to problems through video, animation, simulation, and links that have been observed. Students are able to work on interactive questions independently, and students are able to evaluate learning independently. An e-book is an alternative choice of teaching materials that teachers can use for indirect learning, and can be used by learners to learn at home [25]. E-learning is not limited to geographic barriers. Learning can be done anytime and anywhere so that it can facilitate the learning process [26]. Students can engage in self-learning, and learning resources can be used repeatedly [27].

The product effectiveness test was conducted in two groups, namely the experimental group, and control group. The learning in the experimental group used an interactive electronic book on electromagnetic radiation material, which can be accessed offline or online, while the control group used e-book or BSE PuskurbukElectronic School Book from School and Curriculum Center. Interactive electronic books can be accessed offline because an interactive electronic book is an e-learning tool that provides interactive text, images, animations, videos and quizzes that can be accessed for free. In addition, interactive electronic books can also be accessed online, because interactive electronic books provide links to other learning resources, which must be accessed via web online.

The learning process begins by explaining the learning process that will be done to the students, namely physics learning using the interactive electronic book on electromagnetic radiation material, then students do the critical thinking pretest questions. These pretest questions are intended to find out the initial ability of critical thinking before the use of the interactive electronic book on electromagnetic radiation material. At the end of learning, students are also given posttest to know the achievement of students' critical thinking skill after implementing the learning which uses an interactive electronic book. The use of interactive e-book material is quite effective in fostering students' critical thinking skill. This is supported by previous research on interactive multimedia, that the use of interactive multimedia is more effective in improving critical thinking skill than learning without interactive multimedia [28]. The graph of the comparison of n-gain values in the experimental group and control group for each critical thinking indicators is depicted in (**Figure 3).**

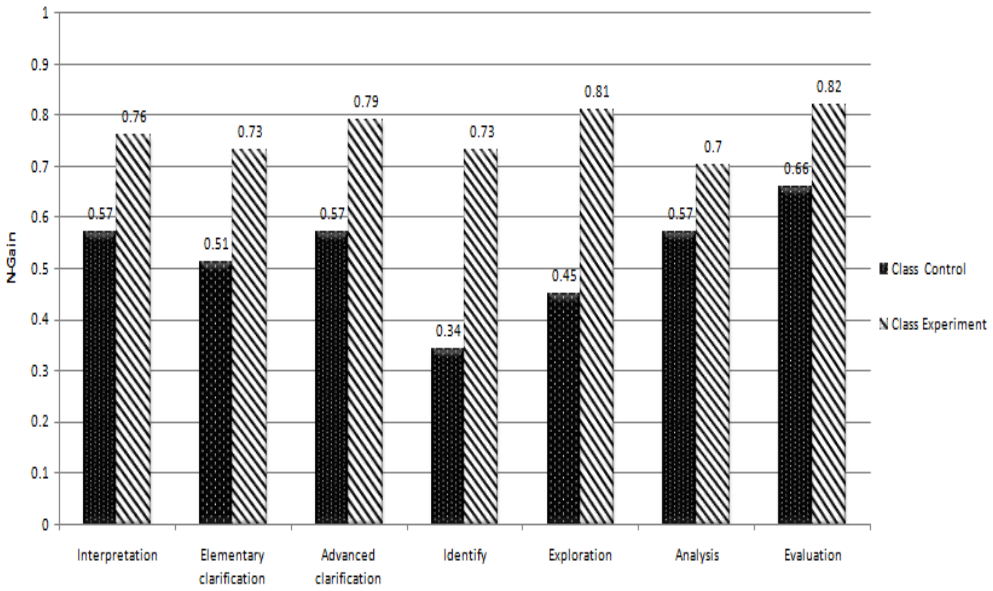

Figure 3 Graph of n-gain value calculation of critical thinking indicator

The analysis result of the first indicator of critical thinking skill is interpretation. The interpretation indicator in the experiment group is higher than in the control group. The indicator of critical thinking interpretation in experiment group shows the result of the pretest score of 11,67; and the posttest average score of 78.4; with n-gain of 0.76; with"high" criteria. The increase indicates that students have been able to provide an interpretation of the problem or problem posed. The ability to interpret is trained in the learning process using interactive electronic books. The interactive electronic book provides pictures, and videos concerning on electromagnetic spectrum, then students are given questions that ask students to express the meaning of the incident. Students are required to be able to express the meaning or intent of the statement, detect information when using interactive electronic books. The explanation concerning critical thinking skill is the ability to analyze, interpret, evaluate information and solve problems [29].

The second critical thinking indicator is elementary clarification. The indicator elementary clarification experiment group better than to the control group. The critical thinking indicator elementary clarification for the experimental group, showing the result of the pretest score obtained by the students of 13.33; and posttest score of 76,67; with n-gain of 0.73; with"high" criteria. The increase indicates that students have been able to elementary clarification the problem or problem posed. The ability to elementary clarification is trained in the learning process using interactive electronic books. The interactive electronic book provides a video about electromagnetic waves, then students are given questions that require explanation. Students are required to be able to reveal the reasons and ideas they have when following the learning process. Activities elementary clarification, students will be able to increase their critical thinking skills [30].

The third critical thinking indicator is advanced clarification. The indicator advanced clarification to the experimental group better than to the control group. The critical thinking indicator advanced clarification in the experimental group, showing the average score of the pretest score obtained by the students of 14.17; and average posttest score of 81,67; with n-gain of 0.79; with"high" criteria. The learning process using interactive electronic books gives students the opportunity to advanced clarification, not just the skill of elementary clarification. Ability to advanced clarification trained in the learning process using an interactive electronic book. The interactive electronic book provides an image of the source of electromagnetic waves, then the students are given questions that require explanation. Students are invited to further explore their abilities while participating in learning activities in an interactive electronic book. Activities advanced clarification conducted, students will be able to increase their critical thinking skills [30].

The fourth critical thinking indicator is identifying the problem. Indicators identify problems in the experiment group better than in the control group. The critical thinking indicator identifies the problem in the experimental group, showing the result of the pretest score obtained by the students of 12.50; and posttest score of 76,67; with n-gain of 0.73; with high criteria. The increase in scores obtained showed that students have been able to identify problems and questions given to students when the learning process takes place. The ability to identify problems is trained in the learning process using an interactive electronic book. The interactive electronic book provides a video about the utilization of electromagnetic waves so that students are interested in solving the problem. Identifying problems is conducted by reflecting material on phenomena that have been provided in an interactive electronic book. Problem identification can help to create an atmosphere of thinking for students [31].

The fifth critical thinking indicator is exploring the problems. Exploring the problems indicator in the experiment group is higher than in the control group. The critical thinking criterion of exploring the problems in the experimental group shows the result of the pretest score obtained by the students of 12.50; and posttest score of 83,33; with n-gain of 0.81; with "high" criteria. The increased score obtained shows that students have been able to explore the problems and questions given to students when the learning process takes place. Exploring problems capability is trained in the learning process using an interactive electronic book. The interactive electronic book provides pictures and videos about the use of electromagnetic radiation, then students are asked to examine the problems concerning on the use of electromagnetic radiation in various fields so that students can explore the problem situation. Exploring problems is conducted by reflecting material on phenomena that have been provided in an interactive electronic book. Students have to be involved in exploration with multiple solutions. Student involvement in exploring problems can help them in developing their critical thinking skills [32].

The sixth critical thinking indicator is analyzing. Analyzing indicator in the experiment group is higher than in the control group. The critical thinking indicator of analyzing in the experimental class shows the result of the pretest score obtained by the students of 14,17; and posttest score of 73,33; with n-gain of 0.70; with "moderate" criteria. The increased score obtained shows that students have been able to analyze the problems, as well as questions given to students when the learning process takes place. Analyzing is conducted by reflecting material on the phenomena that have been provided in an interactive electronic book. Analytical skills are trained in the learning process using the interactive electronic book. The interactive electronic book provides material exposure to the use of electromagnetic radiation. The presentation contains an explanation of the use of electromagnetic radiation, then the students are asked to analyze the use of electromagnetic radiation so that students can understand and declare the intent or meaning of the exposure. Students are required to analyze arguments when using interactive electronic books, identifying actual evidence in everyday life and connecting between concepts. Instructions that support critical thinking use questioning techniques, which require students to analyze, synthesize, and evaluate information to solve problems and make decisions (think), rather than simply repeating information/memorization [7]. Critical thinking suggests an open-minded tendency to analyze to solve the problems [33].

The last critical thinking skill indicator discussed in this research is evaluating. Evaluating indicator in the experimental group is higher than in the control group. The results obtained for the highest critical thinking indicator in the experimental group is evaluating indicator. This is because most students can work on the problem on this indicator. The critical thinking evaluating indicator in the experimental group shows the average pretest score obtained of 17.50; and the mean of posttest score of 85.00; with n-gain of 0.82; with "high" criteria. Interactive electronic book on electromagnetic radiation which has been developed presents the issues that students must solve and gives students opportunities to evaluate their abilities. Evaluation skills are trained in the learning process using an interactive electronic book. The interactive electronic book provides a video of electromagnetic radiation hazards. Furthermore, students are asked to evaluate the dangers posed by electromagnetic radiation in various areas of life, so that students can see the information or state the results of one's thinking. In this evaluating indicator, students can write problem-solving. Students are able to determine the solution and write down the answer to the problem in the questions. This causes most students are able to answer the questions from

the problem in this indicator. The results show an increase in students' ability in evaluating. Students are able to determine the solution, and write down the answer to the problem in the questions. The essence of critical thinking skill is evaluation [34].

Based on Table 8, it is known that all indicators of critical thinking skill in the experimental group have to increase after using an interactive electronic book which has been developed in the learning process. The efforts to establish optimal student's critical thinking skills require interactive learning, students are seen as thinkers rather than individuals who are being taught, and teachers act as mediators, facilitators, and motivators who assist students in the learning [35]. Critical thinking skill is one of the strongest predictors of long-term success in the workplace [36].

4. Conclusion

The conclusion of this research is the systematics of the interactive electronic book on electromagnetic radiation for self-study and to increasing students' critical thinking skill, consisting of the opening chapter which cover the front cover, instruction manuals, study instructions, and content standards. Electromagnetic radiation material in an interactive electronic book is described in the form of interactive text, images, tables, animations, videos and quizzes supported with feedback. Validation results conducted by lecturers and expert practitioners indicate that interactive electronic book on electromagnetic radiation is feasible in terms of content and construction so that interactive electronic book on electromagnetic radiation can be applied. The practicality of the interactive electronic book on electromagnetic radiation consisting of the implementation of learning which is in “high” criteria and student responses are in “very high” criteria. Interactive electronic book on electromagnetic radiation has been effectively used in the learning process and it increased significantly at 95% confidence level with the n-gain value of 0,76 with "high" category compared to control group which has the then-gain value of 0,55 with "moderate" category.

References

[1] T. Wrahatnolo 2018 21st centuries skill implication on the educational system *IOP Conference Series: Materials Science and Engineering*. **296** 1 25-32
[2] D. Ambarwati & A. Suyatna 2018 Interactive design for self-study and developing students’ critical thinking skills in electromagnetic radiation topic *Journal of Physics: Conference Series*. **948** 1 1-8
[3] J. L. S. Ramos, B.B. Dolipas & B.B. Villamor 2013 Higher order thinking skills and academic performance in physics of college students: A regression analysis *International Journal of Innovative Interdisciplinary Research*. **1** 4 48-60
[4] P. Crenshaw, E. Hale & S. L. Harper 2011 Producing intellectual labor in the classroom: The utilization of a critical thinking model to help students take command of their thinking *Journal of College Teaching and Learning*. **8** 7 13-26
[5] M. Kharbach 2012 The 21’s Century Skills Teachers and Students Need to Have *Halifax: Creative Commons Attribution Mount Saint Vincent University*
[6] Anwar, C., Saregar, A & Widayanti 2018 The Effectiveness of Islamic Religious Education in the Universities: The Effects on the Students’ Characters in the Era of Industry 4.0 *Tadris: Jurnal Keguruan Dan Ilmu Tarbiyah*. **3** 1 77–87
[7] K. N. Alotaibi 2013 The effects of blended learning on developing critical thinking ‘skills *Education Journal* **2** 4 176-185
[8] E. E. Peter 2012 Critical thinking: Essence for teaching mathematics and mathematics problem-solving skills *African Journal of Mathematics and Computer Science Research* **5** 3 39-43
[9] A. K. Moody 2010 Using Electronic Books in the Classroom to Enhance Emergent Literacy Skills in Young Children *Journal of Literacy and Technology.* **11** 4 22-52
[10] S. Najihah & I. G. M.Sanjaya 2014 Pengembangan Model E-Book Interaktif Termodifikasi Majalah Pada Materi Struktur Atom *UNESA Journal of Chemical Education*. **3** 3 100-104

[11] T. Darmayanti 2008 Efektivitas intervensi keterampilan self-regulated learning dan keteladanan dalam meningkatkan kemampuan belajar mandiri dan prestasi belajar mahasiswa pendidikan jarak jauh *Jurnal pendidikan terbuka dan jarak jauh.* **9** 2 68-82
[12] G. Gunawan, A. Setiawan & D. H. Widyantoro 2014 Model Virtual Laboratory Fisika Modern Untuk Meningkatkan Keterampilan Generik Sains Calon Guru *Jurnal Pendidikandan Pembelajaran*. **20** 1 25-32
[13] S. Riduwan 2014 *Penelitian Pendidikan Cetakan Ke-20* (Bandung: Alfabeta)
[14] D. E. Meltzer 2002 The Relationship Between Mathematics Preparation and Conceptual Learning Gain in Physics: A Posible Hidden Variable in Diagnostic Pretest Scores *American Journal Physics.* **70** 2 1259-1267
[15] D. A. Nugraha & Wasis 2014 Pengembangan Media E-Book Interaktif Bilingual Pada Materi Pokok Kalor untuk SMA Kelas X *InovasiPendidikanFisika.* **3** 1 1-7
[16] J. O. Djan 2003 Personalising Elektronic Books *Journal of Digital Information.* **3** 4 1-14
[17] W. Saputra & B. E.Purnama 2011 Pengembangan Multimedia Pembelajaran Interaktif untuk Mata Kuliah Organisasi Komputer *Journal Speed-Sentra Penelitian Engineering dan Edukasi*. **4** 2 60-67
[18] D. Zhang, L. Zhou, R. O. Briggs & J. F.Nunamaker 2006 Instructional video in e-learning: Assessing the impact of interactive video on learning effectiveness *Information & Management.* **43** 1 15-27
[19] L. P. Pradina & A. Suyatna 2018 Atom Core Interactive Electronic Book to Develop Self Efficacy and Critical Thinking Skills *TOJET: The Turkish Online Journal of Educational Technology*. **17** 1 17-23
[20] A. Aremuand B. M.Efuwape 2013 A Microsoft Learning Content Development System (LCDS) Based Learning Package for Electrical and Electronics Technology-Issues on Acceptability and Usability in Nigeria *American Journal of Educational Research*. **1** 2 41-48
[21] D. Ardac & S.Akaygun 2004 Effectiveness of Multimedia-Based Instruction that Emphasizes Molecular Representations on Students' Understanding of Chemical Change *Journal of research in science teaching.* **41** 4 317-337
[22] L. Solcovaand M. Magdin 2016 Interactive Textbook-A New Tool in Off-Line and On-Line Education *TOJET: The Turkish Online Journal of Educational Technology*. **15** 3 111-125
[23] F. A. Pradana & A. Suyatna 2017 The Needs of Interactive Electronic School Books to Enhance the Critical Thinking Skills of the Students *Advances in Social Science, Education and Humanities Research (ASSEHR).* **158** 263-271
[24] R. Rosida, N. Fadiawati & T. Jalmo 2017 Efektivitas Penggunaan Bahan Ajar E-Book Interaktif dalam Menumbuhkan Keterampilan Berpikir Kritis Siswa *Jurnal Pembelajaran Fisika.* **5** 1 35-45
[25] M. A. Nurmalia, R. Syamwil & B.Endroyo 2016 Pengembangan E-Book Pembelajaran Berbasis Scientific Kompetensi Keahlian Dasar Teknologi Menjahit untuk SMK Paket Keahlian Tata Busana *Journal of Educational Social Studies.* **5** 1 72-83
[26] M. Saarab, E. Laila & A.Hamza 2012 Mobile Learning (M-Learning) and Education Environment *International Journal of Distributed and Parralel Systems (IJDPS).* **3** 4 31-38
[27] W. Wu & L. Y. Hwang 2010 The effectiveness of e-learning for blended courses in colleges: A multi-level empirical study *International Journal of Electronic Business Management*. **8** 4 312
[28] A. N. Rahma 2012 Pengembangan Perangkat Pembelajaran Model Inkuiri Berpendekatan SETS Materi Kelarutan dan Hasil kali Kelarutan untuk Menumbuhkan Keterampilan Berpikir Kritis dan Empati Siswa terhadap Lingkungan *Journal of Educational Research and Evaluation.* **1** 2 133-138
[29] H. Hyytinen, K. Nissinen, J.Ursin, A.Toom A & S. Lindblom-Ylänne 2015 Problematising the equivalence of the test results of performance-based critical thinking tests for undergraduate students *Studies in Educational Evaluation.* **44** 1-8

[30] K. E. Lestari 2014 Implementasi Brain-Based Learning untuk Meningkatkan Kemampuan Koneksi dan Kemampuan Berpikir Kritis serta Motivasi Belajar Siswa SMP *Judika (Jurnal Pendidikan Unsika).* **2** 1 36-46
[31] A. Karim 2011 Penerapan metode penemuan terbimbing dalam pembelajaran matematika untuk meningkatkan pemahaman konsep dan kemampuan berpikir kritis siswa sekolah dasar *Jurnal Pendidikan* **1** 21- 32
[32] F. Fakhriyah 2014 Penerapan Problem Based Learning dalam Upaya Mengembangkan Kemampuan Berpikir Kritis Mahasiswa *Jurnal Pendidikan IPA Indonesia.* **3** 1 95-101
[33] F. A. Dixon, K. A Prater, H. M. Vine, M. J. Wark, T. Williams, T. Hanchon & C. Shobe 2004 Teaching to their thinking: A strategy to meet the critical-thinking needs of gifted students *Journal for the Education of the Gifted.* **28** 1 56-76
[34] L. G. Snyder & M. J. Snyder 2008 Teaching critical thinking and problem-solving skills *The Journal of Research in Business Education.* **50** 2 90
[35] A. Susanto 2015 *Teori Belajar dan Pembelajaran di Sekolah Dasar* (Jakarta: Prenada media Group)
[36] J. C. Rode, M. L. Arthaud Day, C. H. Mooney, J. P Near & T. T. Baldwin 2008 Ability and personality predictors of salary, perceived job success, and perceived career success in the initial career stage *International Journal of selection and assessment* **16** 3 292-299