The Effectiveness of CTL-based Physics E-module on the Improvement of the Creative and Critical Thinking Skills of Senior High School Students

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Abstract **– This study aimed to determine the effectiveness of the CTL-based physics e-module in improving the creative and critical thinking skills of senior high school students. Consequently, an experiment with a pretest-posttest control group design was conducted using two groups of 60 tenth-grade students majoring in Science. The experiment consisted of an assessment of creative and critical thinking skills, as well as test questions. Subsequently, the data obtained from the assessment was analyzed using the t-test and N-Gain, and the results showed that the scores of students' creative and critical thinking skills in the experimental group at the end of the treatment were 81.85 and 81.81. Furthermore, the N-Gain scores for the two skills in the experimental group were 0.60 and 0.59. However, there were significant differences in the levels of creative and critical thinking skills of students using the CTL-based physics e-module with the control group (p=0.000). The experimental group had an average cognitive competence score of 78.50 and a completion rate of 93.34%.**

The study concluded that the e-module is effective in improving creative and critical thinking skills as well as student learning outcomes in physics education, especially during the aftermath of COVID-19.

Keywords **– Creative, Critical, Contextual Teaching and Learning, e-Learning, E-module.**

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1. Introduction

The emergence of the COVID-19 pandemic had an impact on human social activities all over the world, particularly in the field of education [1], which led to the implementation of numerous policies by many countries to address the situation, including the closure of schools and the replacement of traditional education with e-learning [2]. According to intensive studies conducted on the feasibility of e-learning for students' academic progress, the incorporation of technology into learning appears to be the only solution for the education sector, which confirms that the incorporation of technology into learning has become a requirement in the 21st century.

The fourth industrial revolution is similar to the technological disruption of the 21st century, and the purpose of learning physics in schools during this era is not only to provide students with a basic understanding of physics but also students with 4C skills as a recognized standard [3]. Students have to acquire these skills to help them understand how to apply their knowledge. Furthermore, these skills have become "mandatory" to learn in schools because they are necessary to equip students in various industries and guarantee their future success [4]. These skills include creative thinking, critical thinking, collaboration, and communication.

The two phenomena above explain how current physics learning has to be implemented by integrating technology, developing 4C skills, and adopting a relevant pedagogical approach. Physics

education is expected to be more meaningful, relevant, and inspiring to students in today's global pedagogical system and taught in real-world contexts [5]. However, the decontextualization of learning has persisted in science classrooms in recent times [6]. Additionally, the memorization of concepts and formulas is an example of this traditional pedagogical approach, particularly in physics education [7].

This traditional pedagogy persists today, despite the use of digital platforms to implement e-learning [3] because the teachers make use of materials that do not support the innovative learning processes and are not relevant to current learning facilities [8]. Furthermore, they not only use textbooks from publishers, which are incompatible with e-learning facilities but are accustomed to explaining the material through the creation and upload of videos to YouTube, where students can view them. Subsequently, students are expected to complete practice questions, which leads to poor grades, and this is the main reason of physics teachers still having difficulty developing students' 4C skills, particularly creative and critical thinking skills [9]. Teachers have difficulty creating teaching lessons, particularly when it concerns materials that are contextual, integrated with ICT, and capable of developing students' creative and critical thinking skills. These two skills are the main high-order thinking skills (HOTS) that students need to learn physics today because the knowledge gained through a learning process focused on improving creative and critical thinking skills is more comprehensive [10]. Consequently, these two skills are fundamental skills that students have to acquire in this era to make physics learning easier. Creative thinking skills are necessary for problem-solving and the generation of original, unique, and useful ideas. Critical thinking skills include analytical thinking, evaluation, inference, deduction, and inductive reasoning [11]. The indicators of the two skills are shown in the Table 1. These skills are developed through a process that includes several stages, such as problem analysis, developing hypotheses, evaluating, and communicating results [12]. Furthermore, these studies show that the development of creative and critical thinking skills cannot be accomplished through learning that consists solely of the presentation of basic facts and content.

Table 1. Indicators of Creative and Critical Thinking Skills

Aspect	Indicator
Creative Thinking Skills	Outline ideas clearly Pouring out original ideas Provide various interpretations of a problem Dig up information from various sources as a reference for solving problems Implement existing knowledge in solving a problem Create something new, unique, and unthinkable by others
Critical Thinking Skills	Evaluating other people's arguments Provide feedback on arguments submitted by others Deliver an explanation (deductive or inductive). Summarizing the quality of an information Understand how to use knowledge from one situation to another Understanding the questions that other people ask Asking a question to clarify Interpreting information

Source: [13]

This concept demonstrates the importance of implementing e-learning materials, such as e-modules, which are characterized by high content quality, technical quality, pedagogical efficiency, interoperability in the technology used, contextual relevance, and low cost. E-modules are electronic-based teaching materials designed to enable students to learn independently, with or without the assistance of a teacher. The use of content that contains text, images, graphics, sound, video, and animations for learning can be easily arranged and improve concept mastery and student learning outcomes [14]. Furthermore, this method is accompanied by several characteristics, including easy storage on a flash drive, portability, on and offline usage, and ease of accessibility [15]. Consequently, it can be used as a teaching material that incorporates systematic independent learning activities to achieve instructional goals and is relevant to the anticipated e-learning activities.

Contextual Teaching and Learning (CTL) has been identified as an approach to make physics learning more meaningful for students in response to public expectations for physics learning to be relevant and inspiring to students. This approach is achieved by subjecting physics learning to a real and interesting environment [16]. Additionally, CTL is a method for presenting real-life scenarios in the classroom, and it

aims to stimulate students to connect their knowledge with their surroundings, hence they can experience impactful learning [17]. It is also critical to emphasize the connection between real life and physics to ensure students master physics more comprehensively [18].

CTL focuses on the entire process of student involvement to relate the material being studied to real-life situations so that students can discover meaningful connections between abstract ideas and practical applications in real-world contexts through CTL-based learning. Additionally, they identify concepts through discovery, reinforcement, and connection to discover what the material entails and how it affects life [19]. Previous studies show that CTL can aid in the development of students' creative [20] and critical thinking skills [21].

The integration of the CTL approach into e-modules is a solution that can be implemented today. Consequently, an evaluation of the effectiveness of the CTL-based physics e-module in improving creative and critical thinking skills and student learning outcomes was conducted in this study. There is hope that the CTL-based physics e-module will aid in the smooth and effective execution of learning activities in schools, as well as the achievement of 21st-century learning goals.

2. Method

This study employed a quasi-experimental design with a non-equivalent pretest-posttest control group, and a pre-test, treatment, and post-test were administered to the group (Creswell, 2012). The activity began with a pre-test to review the students' creative and critical thinking skills before treatment was given, and this review was conducted through the observation of their e-learning activities using performance and peer assessment instruments. The CTL-based physics e-module was implemented during the treatment stage, fulfilling its role and function as an accommodator of students' e-learning activities. Furthermore, this stage was applied for five meetings, and the post-test results were based on the results of the previous meeting's performance and peer assessment. Subsequently, a CTL-based physics e-module was created in this study using the Lectora Inspire 17 software, and some screenshots of the interface are shown in Figure 1. The activity's learning material, which entailed global warming, began with students reading articles about global warming to attract their interest and then obtaining a summary of their discovery. The second stage involved students watching contextualized videos and drawing important conclusions from their observations. The third phase involved group discussion about the contextualized videos, while conclusions were made in the fourth phase. The students answered practice questions in the last stage.

This study was conducted at the State High School (SMAN) 2 Bukit Tinggi during the academic year 2021/22, with the school's population comprising 160 10th grade MIA (Science major) students for that academic year. The sample was chosen using a purposeful sampling technique, which included special considerations and criteria incorporated with normal and homogeneous learning outcomes to obtain representative data [22]. Furthermore, 60 students from MIA 2 and MIA 4 in the 10th grade were sampled. The experimental group, which was MIA 2, received treatments through the application of CTL-based E-modules, while the control group, which was MIA 4, utilized publisher textbooks.

The data collection instrument employed for this study was an assessment of creative and critical thinking skills, as well as test questions, which are found on the 21st Century Skills Assessment Sheet, consisting of a performance and a peer evaluation. The 21st Century Skills instrument indicators are usually employed in these types of studies to develop creative and critical thinking skills [3]. Furthermore, the test questions were first evaluated using the product-moment correlation formula, yielding 15 valid and 5 invalid questions. Subsequently, the 15 questions were evaluated using the K-R 20 formula, which gave a reliability coefficient of 0.95.

The SPSS 22 for Windows was used to analyze the data, and the criteria for decision-making was that the data should be accepted if the significant value (p) on the SPSS output was less than 0.05. The Equation 1 was used to analyze the creative and critical thinking skills, as well as student learning outcomes. 21st Century Skills Assessment is categorized based on the classification in Table 2. Gain analysis was used to measure the increase in students' creative and critical thinking skills with the Equation 2. This increase was evaluated based on the category in Table 3.

$$N = \frac{Score\ obtained\ by\ students}{Maximum\ Score} \times 100 \ldots\ldots (1)$$

$$\langle g \rangle = \frac{\langle Skor_{post} \rangle - \langle Skor_{pre} \rangle}{100\% - \langle Skor_{pre} \rangle} \ldots\ldots\ldots\ldots (2)$$

Table 2. Classification of Creative and Critical Thinking Skills

Interval	Category
0 ≤ N ≤ 29	Bad
30 ≤ N ≤ 64	Less good
65 ≤ N ≤ 79	Pretty good
80 ≤ N ≤ 89	Good
90 ≤ N ≤ 100	Very good

Table 3. Category for Improving Creative and Critical Thinking Skills

Interval	Category
$g > 0.7$	High
$0.3 < g < 0.7$	Moderate
$g < 0.3$	Low

According to the description above, the CTL-based physics e-module was declared effective if the students' creative and critical thinking skills scores at the end of the treatment in the experimental group were in the good or very good category, and if the score for improving creative and critical thinking skills in the experimental group was in the moderate or high category. Furthermore, the e-module was deemed effective if there were differences in the levels of creative and critical thinking skills of students in the control group, the average score of cognitive competence in the experimental group reached a score of 75, and 70% of students were declared complete.

Figure 1. Representative screenshots of CTL-based physics e-module

3. Result and Discussion

▪ Results of Creative Analysis and Critical Thinking Skills

The achievement results of students' creative and critical thinking skills were obtained by observing the indicators of these competencies during the learning process using performance and peer assessments. Furthermore, Figure 2 and Figure 3 show the results obtained in each class, indicating that the creative and critical thinking skills of students in the experimental and control groups improved after five meetings, although the improvement in the control group was not statistically significant.

According to the data provided, both the experimental and control groups were presented with relatively similar pre-test results and remained in the poor category. Furthermore, the results of observations on students' creative and critical thinking skills remained in the poor category after the first and second meetings. The role of the CTL-based physics e-module in improving students' creative and critical thinking skills is still uncertain because the indicator that shows the results of creative thinking skills cannot be considered significant even though it is assigned to the "good enough" category.

This result was obtained because the students were still adapting to this e-module and they were not used to presenting their ideas in detail. The previous learning environment, which did not require students to complete this activity, had a significant impact on this outcome. Furthermore, this activity is important for the development of creative and critical thinking because it encourages students to think comprehensively and actively participate in learning [23].

Subsequently, the two skills in the experimental group began to improve as the meetings went on. Previous learning experiences make this improvement more likely [24]. The CTL approach provides an enjoyable learning experience because it provides benefits, such as reduced learning anxiety, easy adaptation to the student environment, and room for deep thinking [21]. Additionally, the CTL approach instructs the students on how to master the entire learning content. The presence of observation and discussion sections based on the CTL approach enables teachers to improve critical thinking skills [25] and creative thinking skills [20].

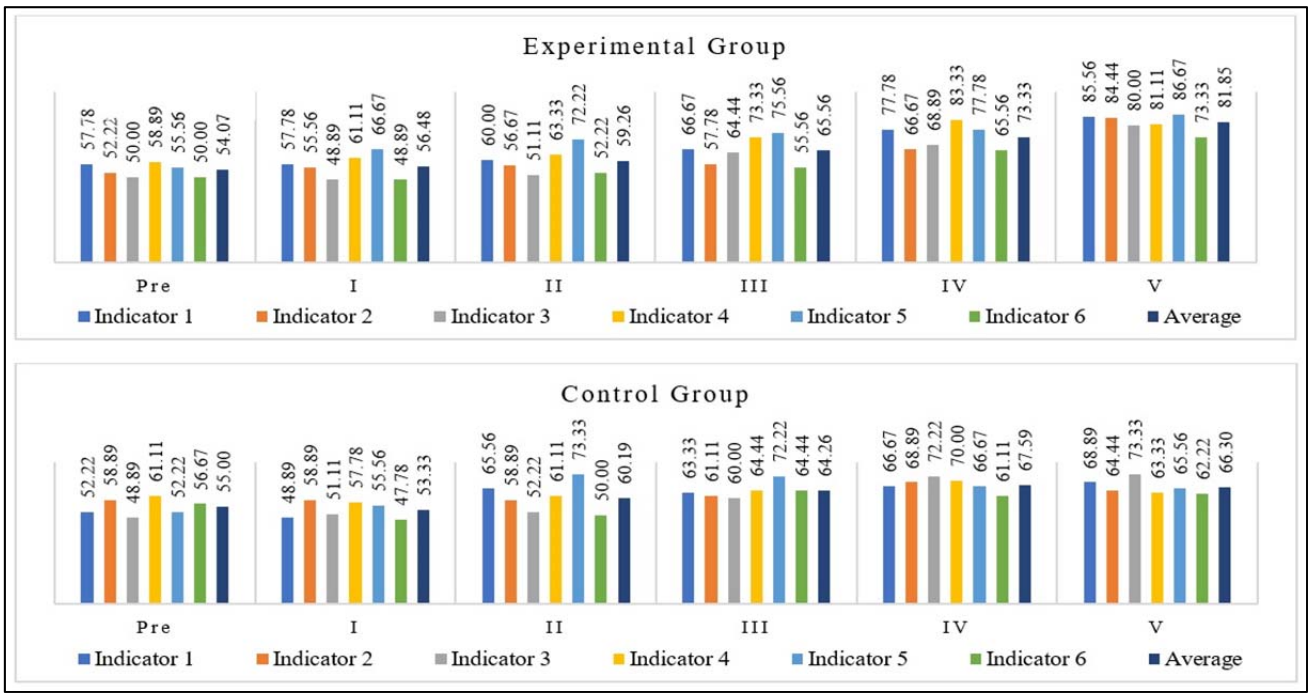

Figure 2. Creative thinking skills scores

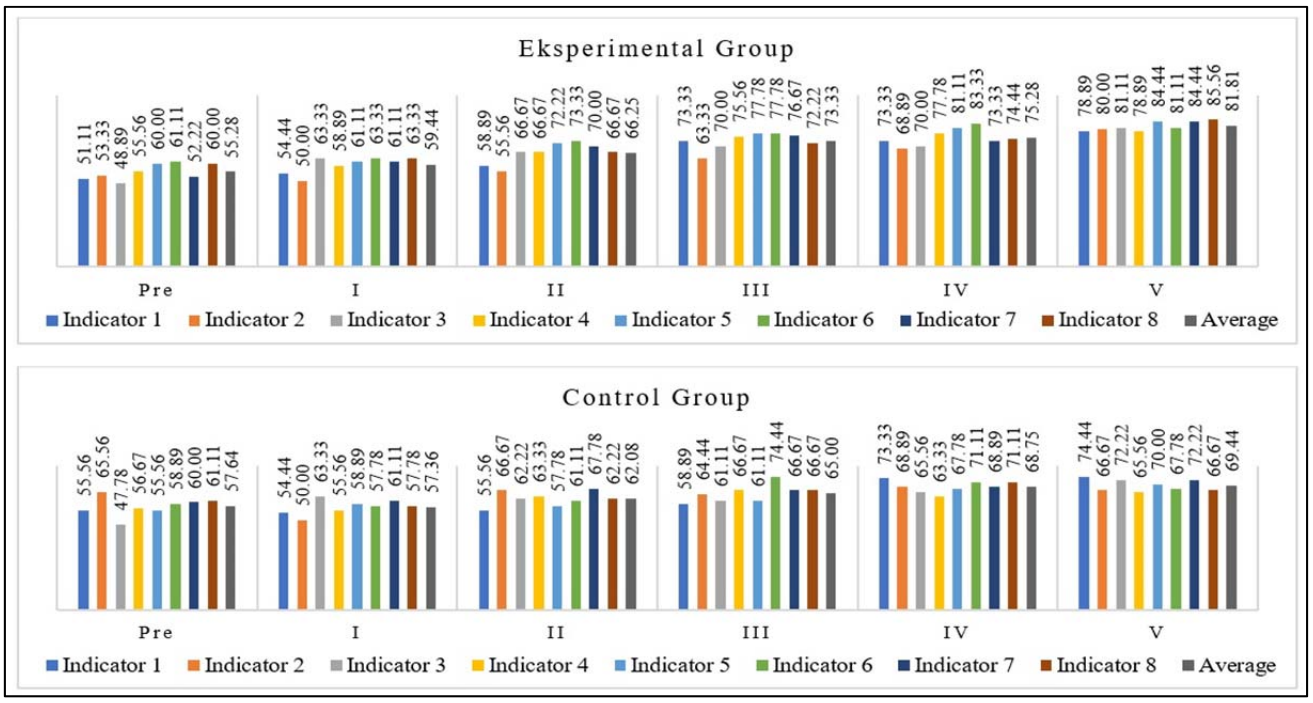

Figure 3. Critical thinking skills scores

Table 4. The score of N-Gain Creative and Critical Thinking Skills

Group	N-Gain Creative Thinking Skills Score						Average	N-Gain Critical Thinking Skills Score								Average
	1	2	3	4	5	6		1	2	3	4	5	6	7	8	
Experiment	0.66	0.67	0.60	0.54	0.70	0.47	0.60	0.57	0.57	0.63	0.53	0.61	0.51	0.67	0.64	0.59
Control	0.35	0.14	0.48	0.06	0.28	0.13	0.25	0.43	0.03	0.47	0.21	0.33	0.22	0.31	0.14	0.28

The role of CTL-based physics e-modules to help educators accommodate student-centered pedagogy is evident at the meetings conducted, particularly in terms of students' digital communication skills in expressing their ideas clearly, uniquely, and using a variety of sources. The integration of ICT into the development of student-centered modules with effective approaches and learning strategies has the potential to increase student engagement in learning activities [26]. Furthermore, the social interaction allowed by the CTL-based physics e-module for students to express their ideas and opinions, gather information, and discuss has a significant impact on this improvement and improves students' creative and critical thinking skills [27]. This is because the use of digital platforms promotes student self-efficacy, which in turn improves students' creative and critical thinking skills [28].

The first phase of the CTL-based physics e-module activity ensured that the students were given enough time to read articles about global warming, allowing them to gain prior knowledge and increase their effectiveness in achieving learning objectives [29]. They were also trained to summarize the key points and use them to make deductive or inductive explanations and interpret information. These activities are critical in developing critical thinking skills [30]. Students were exposed to contextual-based videos in the second phase of the program to help them interpret what they read about. Furthermore, this activity can help develop critical thinking skills because it requires making deductive or inductive explanations and interpreting information. Students conducted discussions digitally through e-learning facilities in the third phase and answered questions about the video presented in the second phase. These activities teach them how to think creatively and critically [31]. The activities facilitated by digital tools also provide efficiency and effectiveness in conveying ideas in this generation [32]. Consequently, this activity can help to develop these skills digitally. Conclusions were made by the students in the fourth phase. The objective of phases one and two was to enable students to make deductive or inductive explanations and interpret information. Furthermore, students are used to brainstorming at the end of their studies, so this activity aimed to help them develop their creative thinking skills [33]. According to these phases, it is logical to conclude that activities in the CTL-based physics e-module form an effective learning environment to accommodate e-learning activities and become a key success factor in developing students' creative and critical thinking skills.

Generally, the results displayed in Figure 2 and Figure 3 indicates that students' creative and critical thinking skills improved with each meeting. It is clear that students' creative and critical thinking skills improved significantly after comparing the pre-treatment and post-treatment results after five meetings, with N-Gain scores above 0.50 in the experimental group. Table 4 shows the N-Gain scores for each class.

- **Analysis of the Effect of CTL-based Physics E-module**

The SPSS 22 application for Windows was used for this analysis, and prerequisite tests, such as the normality and homogeneity tests, were conducted before testing the hypothesis. The Kolmogorov-Smirnov test and Levene's test were used to determine normality and homogeneity, respectively. Subsequently, the level of significance in both tests was set at 0.05, and the results are displayed in Table 5 and Table 6. The four data groups obtained a significance greater than 0.05 based on the results of the Kolmogorov-Smirnov test, which indicated that the data group was normally distributed. Furthermore, Levene's Test yielded F values of 0.003 and 3.003, and significance levels of 0.956 and 0.088, which indicated that the data group was homogeneous. According to the results of this prerequisite test, the data is normally distributed and homogeneous, so hypothesis testing can be performed using a parametric test, also known as the t-test.

Table 6 shows that the two groups differed significantly in terms of creative and critical thinking skills (Sig. (2-tailed) < 0.05), which means that H1 is acceptable, but students in both groups have varying levels of proficiency in these two skills. Furthermore, the CTL-based physics e-module is more effective than printed books from publishers to improve students' creative and critical thinking skills.

The student learning outcomes, which show satisfactory results in terms of knowledge, can be seen in Table 7. This is due to context-based learning, which provides more relevant and complete examples to help students master the learning content and gain real-life experience [34]. These conditions certainly boost students' motivation to engage in learning activities. Furthermore, the e-learning

design, which is provided by the CTL-based physics e-module, provides quality content, pedagogical efficiency and facilitates learning for students [35].

The integration of contextual problems into the e-module can help students develop meaningful and in-depth knowledge.

Table 5. Tests of Normality

		Experiment Class		Control Class	
		Creative	Critical	Creative	Critical
N		30		30	
Normal Parameters a,b	Mean	81.8463	81.8073	66.2983	69.4410
	Std. Deviation	5.50602	5.16358	5.93020	6.94408
Most Extreme Differences	Absolute	0.121	0.153	0.093	0.142
	Positive	0.118	0.119	0.093	0.100
	Negative	-0.121	-0.153	-0.056	-0.142
Kolmogorov-Smirnov Z		0.662	0.837	0.509	0.775
Asymp. Sig. (2-tailed)		0.773	0.485	0.958	0.585

Table 6. Results of t-test

		Levene's Test		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Creative Thinking Skills	Equal variances assumed	0.003	0.956	10.52	58	0.000	15.54	1.47	12.59	18.50
	Equal variances not assumed			10.52	57.68	0.000	15.54	1.47	12.59	18.50
Critical Thinking Skills	Equal variances assumed	3.003	0.088	7.827	58	0.000	12.36633	1.57	9.20	15.52
	Equal variances not assumed			7.827	53.56	0.000	12.36633	1.57	9.19	15.53

Table 7. Completeness of Student Learning Outcomes

Average	Complete	Not Complete	Completeness Percentage
78.4917	28 students	2 students	93.34%

According to the factors presented above, the CTL-based physics e-module is highly qualified to be used as the best solution for presenting teaching strategies that address the challenges of the 21st-century. Consequently, students can develop their creative and critical thinking skills and improve their learning outcomes. Additionally, this e-module can be widely used to present e-learning with certain benefits, such as content quality, technical quality, pedagogical efficiency, interoperability in the technology used, contextuality, and low cost.

4. Conclusion

According to the results obtained from the treatments, the implementation of the CTL-based physics e-module was effective in improving creative and critical thinking skills, as well as student learning outcomes. The scores for the two skills at the end of the treatment in the experimental group were 85, indicating that they were in the “good” category. However, the N-Gain scores for creative and critical thinking skills in the experimental group were 0.60, which was presented in the “moderate” category. The level of skill when using the CTL-based physics e-module with the control group varied. Furthermore, the experimental group had an average cognitive competence score of 79.30 and a completion rate of 93%. Consequently, this study contributed to ways to implement effective e-learning and can be considered by policymakers to accommodate e-learning activities with certain benefits, such as content quality, technical quality, pedagogical efficiency, interoperability in the technology used, contextuality, and low cost.

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