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The Implementation of WE-ARe Learning Model toward the Critical Thinking of Pre-service Biology Teachers

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ABSTRACT

By implementing a learning model that cultivates 21st-century skills, students' critical thinking skills can be enhanced. One of the alternative learning models that can be used to accommodate this is the WE-ARe learning model. This study is quasi-experimental, with a pretest-post-test control group design. The participants consisted of all biology education students from IAIN Ternate and STKIP Kie Raha in Ternate City, North Maluku, Indonesia. The research sample consisted of sixty biology education students. Essay test questions were used to evaluate participants' critical thinking skills. The significance level for the covariate analysis (ANCOVA) was set at 5%. The analysis revealed that the WE-ARe learning model positively influenced the critical thinking skills of pre-service biology teachers, where the experimental group obtained a higher mean score (81.714) than the positive (66.9995) or negative control (33.858) groups. Future use of the WE-ARe learning model as an alternative learning model to prepare students with 21st-century skills and life skills is anticipated at both the secondary and undergraduate levels.

Keywords: *Critical thinking skills, WE-ARe Learning Model, pre-service biology teachers, 21st-century skills.*

1. INTRODUKCTION

Meaningful learning will have a positive impact on students' thinking abilities. Critical thinking helps an individual face the challenges of a globalized world [1]. Critical thinking is defined as a person's ability to examine an event or a condition, analyze an opinion, and decide based on prior knowledge [2].

Critical thinking refers to the ability to access, analyze, and synthesize information [3]. This ability is also related to communication and information skills. The digital literacy era with diverse sources of information presents a challenge for students to be able to select relevant and appropriate sources and information based on their needs, locate quality sources, and provide evaluations on aspects of objectivity, reliability, and data updating. To become successful lifelong learners in the 21st century, students must have strong critical thinking and literacy skills [4], [5]. Critical thinking enables students to rationally process information and prepare for independent study [6]. Students with critical thinking skills can distinguish information based on its importance and relevance [7], [8].

Critical thinking basically involves the process of identifying and analyzing sources of information for credibility. Critical thinking demonstrates the capacity to utilize prior knowledge and draw connections and conclusions [9]. Enhancing logical reasoning skills can enhance critical thinking skills. Paul & Elder describes several roles and functions of critical thinking skills, where each function represents an important part of the quality of thinking and overall outcomes. These roles and functions include: (1) questioning problems; (2) goals;

(3) information in the form of data, facts, observations, experiences or other sources that can help someone solve their problems; (4) a concept in the form of a mindset that becomes a framework for thinking and acting; (5) assumptions that describe the rationale; (6) point of view in reasoning and thinking which involves the process of interpreting and understanding something; (7) interpretation and inference which serves to understand the data and draw conclusions; and (8) implications and consequences in the form of readiness to face the implications and consequences of the thinking process [10]. The application of critical thinking in biology classes can provide students with opportunities to develop analytical, inductive, and deductive thinking skills to solve fundamental everyday problems [11]. In a learning environment, students with strong critical thinking skills demonstrate greater self-assurance by viewing themselves as individuals who can actively contribute to the learning process.

According to previous research, university students score poorly on every indicator of critical thinking ability [12]–[15]. Surveys indicate that students' critical thinking skills remain underdeveloped because the materials and learning strategies employed in the classroom are not conducive to the development of students' critical thinking abilities [16], [17]. The critical thinking and critical analysis skills of aspiring biology teachers continue to be underdeveloped [18]. Students' higher order thinking skills are still in the low range, with self-regulated thinking at 59%, critical thinking at 58%, and self-regulated thinking at 57% [19]. The ability of biology department students to ask and consider questions remains low [20], [21]. These findings suggest the need for the application of active and innovative learning models in the classroom to strengthen students' critical thinking skills. The syntax of a learning model provides students with a unique and distinct experience and influence an individual's cognitive capacity [22].

Critical thinking skills do not develop by itself as people age and grow. This cognitive ability will flourish if it is stimulated and purposefully enhanced [23]. Critical thinking is a domain of higher-order thinking that must be taught to students continuously through the selection of suitable learning models [7], [24]–[26]. Enhancing critical thinking requires a learning model that can facilitate student learning activities, where they can produce logical and rational arguments, make reflective decisions, and evaluate what they should do or believe [27]. Finding the ideal learning model to develop students' critical thinking skills is a challenging task for most educators [19], [28].

The WE-ARe learning model is a constructivist-based active learning model that consists of warm-up, exploring, argumentation, and resume phases [29]. The learning model has been shown to increase pre-service biology teachers' learning motivation and critical thinking skills [30]. The WE-ARe learning model enhances self-assurance and generates positive energy in the learning environment, thereby promoting students' learning progress because they have a positive outlook on their academic success. The stages of the WE-ARe learning model (Warm-up, Exploring, Argumentation, Resume) increase biology students' self-efficacy [29]. WE-ARe is believed to have the potential to promote pre-service biology teachers' critical thinking skills in Ternate, North Maluku.

The problem statement of this study is "Does the WE-Are learning model have an effect on pre-service biology teachers in Ternate, North Maluku?" The purpose of the study was to identify the effect of the WE-Are learning model on the critical thinking skills of pre-service biology teachers in Ternate, North Maluku. It is anticipated that the findings of this study will assist educators and lecturers in designing learning that can stimulate students' critical thinking, thereby increasing the competence of the biology teachers, particularly in facing the challenges of the 21st century.

2. METHODS

This study was a quasi-experimental study, using WE-ARe learning model as the independent variable and critical thinking skills as the dependent variable. A pretest-posttest control group design was used (Sugiyono, 2009).

Table 1. The Pretest-Posttest Control Group Design

Group	Pre-test	Treatment	Post-test
Experimental	O_1	WE-ARe	O_2
Control Positive	O_3	STAD	O_4
Control Negative	O_5	Conventional	O_6

Notes:
O_1 = Pretest score of the experimental group (implementing the WE-Are learning model)
O_2 = Post-test score of the experimental group (implementing the WE-ARe learning model)
O_3 = Pretest score of the positive control group (implementing STAD)
O_4 = Post-test score of the positive control group (implementing STAD)
O_5 = Pretest score of the negative control group (implementing conventional learning)
O_6 = Post-test score of the negative control group (implementing conventional learning)
X = Treatment (implementing the WE-Are learning model)

The research population contained all students from the Department of Tadris Biology at IAIN Ternate and STKIP Kie Raha, Ternate, North Maluku. The research sample consisted of 60 four-semester students from the Department of Tadris Biology. These students were assigned into three treatment classes. The study was conducted during the even semester of the 2021/2022 academic year. Prior to determining the sample, equivalence test was conducted to the students. The test was done by distributing a placement test.

The research instrument consisted of a critical thinking test. The test underwent validity testing and empirical testing. The results of the validity tests showed that the instrument was valid and reliable for use in the research. Data on the participants' critical thinking skills were gathered using an essay test. The participants' answers were evaluated using a critical thinking rubric developed by Zubaidah, Corebima, & Mistianah as an adaptation from the Critical Thinking Essay Test and Guidelines for Scoring Illinois Critical Thinking Essay Test. The rubric used a 0-5 scale [31].

The research data were collected using a pretest, observation, and a post-test. The data were analyzed using descriptive and inferential statistics. The descriptive analysis resulted in the students' critical thinking profile, while the inferential statistics was used to test the effect of the WE-ARe learning model on the students' critical thinking skills. The research hypothesis "The WE-Are learning model has an effect on pre-service teachers' critical thinking skills in Ternate, North Maluku" was analyzed using ANCOVA at the significance level of 5%. ANCOVA was run in SPSS. Prior to analyzing the data with ANCOVA, One-Sample Kolmogrov-Smirnov test and Levene's Test of Equality of Error Variances were performed to examine the normality and homogeneity of the data.

3. RESULTS

3.1 Descriptive Analysis of the Research Data

Descriptive analysis was done to examine the students' pre and post-test scores on critical thinking skills. Table 2 displays the minimum, maximum, and mean scores as well as the standard deviation obtained by the experimental and control groups.

Table 2. The Results of the Descriptive Analysis on the Experimental, Positive Control, and Negative Control Groups' Pretest and Post-test Scores

Descriptive Statistics	Experimental Group WE-ARe		Positive Control Group STAD		Negative Control Group Conventional	
	Pretest	Posttest	Pretest	Posttest	Pretest	Posttest
N	20	20	20	20	20	20
Minimum	14.29	77.14	14.29	60	17.14	28.57
Maximum	31.43	88.57	31.43	77.14	28.57	42.86
Mean	22.285	81.714	23.428	66.999	22.570	33.858
Std.Deviation	4.86896	3.51791	4.20629	4.39413	3.19685	4.56785

Table 2 explains that on the pretest, the experimental group obtained a mean score of 22.285 with a standard deviation of 4.86896, meanwhile the positive control obtained a mean score of 23.428 with a standard deviation of 4.20629, and the negative control got a mean score of 22.570 with a standard deviation of 3.19685. These figures suggest that prior to the treatment, all participating groups had equivalent critical thinking skills, indicated by their similar mean scores on the pretest.

However, on the posttest, the experimental group obtained a mean score of 81.714 with a standard deviation of 3.51791, meanwhile the positive control obtained a mean score of 66.999 with a standard deviation of 4.39413, and the negative control got a mean score of 33.858 with a standard deviation of 4.56785.

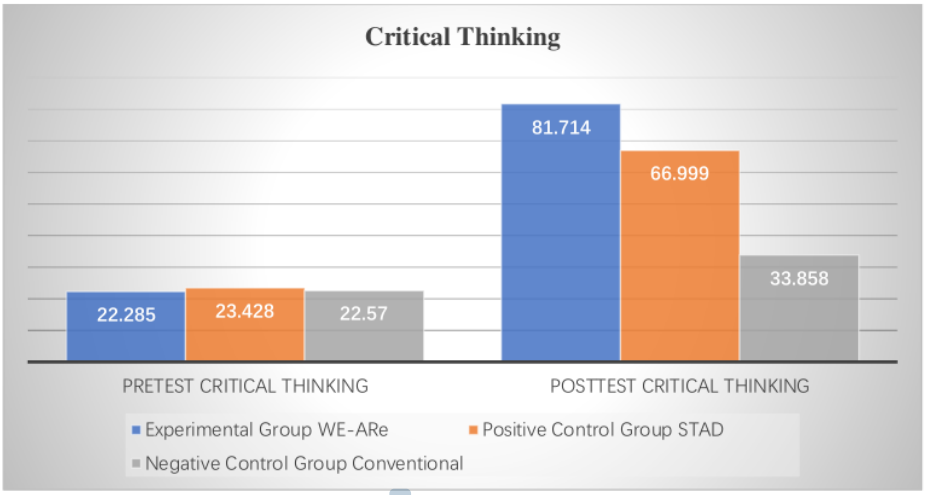

Figure 1. The Students' Pretest and Post-test Scores of Critical Thinking Skills

3.2 The Assumption Tests

Before conducting the covariance analysis, data normality and homogeneity of the variance were examined. The data normality was tested using the *Kolmogorov-Smirnov* method with α=0.05, where significance level (p) >0.05 showed that data had normal distribution and p<0.05 showed that data did not have normal distribution. Data that had normal distribution were then analyzed using parametric analysis, while data that did not have normal distribution were examined using non-parametric analysis. The homogeneity of the variance was tested using the Levene's test, where significance level (p) >0.05 was considered homogeneous and p<0.05 was considered non-homogeneous.

3.2.1 Test of Normality

The results of the normality test of the experimental and control groups' data using Kolmogrov-Smirnov are presented in Table 3.

Table 3. Results of the Normality Test

Score	Groups	Kolmogorov-Smirnova	Sig.	Remarks
Critical Thinking Skills-Pretest	The experimental group (WE-Are)	0.181	0.086	Normal Distribution
	The positive control group (STAD)	0.154	.200*	Normal Distribution
	The negative control group (conventional)	0.189	0.058	Normal Distribution
Critical Thinking Skills-Posttest	The experimental group (WE-Are)	0.187	0.065	Normal Distribution
	The positive control group (STAD)	0.14	.200*	Normal Distribution
	The negative control group (conventional)	0.162	0.176	Normal Distribution

Table 3 shows that, on the pretest and post-test, the significance level (p-value) of each treatment group was bigger than 0.05 (p>0.05); hence, it was concluded that the research data were distributed normally.

3.2.2 Test of Homogeneity

The results of the homogeneity test of the experimental and control groups' data using Levene's test are presented in Table

Table 3. Results of the Normality Test

Variables	Levene's Statistics	Sig.	Remarks
Critical Thinking Skills-Pretest	1.728	0.187	Homogeneous variance
Critical Thinking Skills-Posttest	0.647	0.528	Homogeneous variance

Table 4 shows that, on the pretest and post-test, the significance level (p-value) of each treatment group was bigger than 0.05 (p>0.05); hence, it was concluded that the research data (pretest and post-test data of all treatment groups) had homogeneous variance.

3.2.3 *Hypothesis Testing*

The research hypothesis was examined using analysis of covariance (ANCOVA). The analysis of covariance was done to investigate the effect of the WE-ARe learning model on the participants' critical thinking skills, with the pretest score as the covariance. The results of the ANCOVA conducted in this study are summarized in Table 5.

Table 5. The Results of ANCOVA

Tests of Between-Subjects Effects

Dependent Variable: Posttest Critical Thinking

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	24035.327[a]	3	8011.776	450.044	.000
Intercept	6997.796	1	6997.796	393.086	.000
Pretest_Critical_Thinking	1.512	1	1.512	.085	.772
Group	24032.610	2	12016.305	674.989	.000
Error	996.924	56	17.802		
Total	247247.935	60			
Corrected Total	25032.251	59			

a. R Squared = .960 (Adjusted R Squared = .958)

Table 5 explains the difference in critical thinking skills between the experimental and control groups following the research treatment. It was found that the F-calculated was 674.989 and the significance value was 0.000. Since the significance value was smaller than the alpha 5% or 0.05, it was concluded that there was a difference in critical thinking skills between the experimental and control groups. In short, it can be said that the research treatment, namely the implementation of the WE-Are model, had a significant effect on students' critical thinking skills.

Among the treatment groups, the experimental group achieved the highest mean score (81.714), followed by the positive control group (66.9995), and the negative control group (33.858). Based on the analysis, it can be said that the implementation of the WE-Are learning model was effective in enhancing pre-service biology teachers' critical thinking skills, compared to STAD and conventional learning. It has been demonstrated that the stages of the WE-Are learning model can stimulate the development of critical thinking skills in university students. The research participants initially had difficulty asking questions. They were typically passive in argumentative discussions. However, as the lecturer provided scaffolding, the students gradually gained the confidence to actively participate in class discussions and were even able to provide feedback during the learning process. The lecturer shared website links to lecture-related materials, allowing students to easily access learning materials. In addition, students were also provided with e-book files related to the learning material. This was intended to increase students' interest in reading, particularly during the WE-ARe learning model's warm-up phase.

Next, the lecturer provided scaffolding to build the students' confidence in asking questions by having them compose questions in their notebooks. The lecturer then instructed the students to take turns reading the previously written questions. This learning activity taught students to ask questions with confidence. During this phase, the lecturer could identify and observe the level of questions posed by students, i.e., whether these questions required lower or higher order thinking skills. The lecturer then provided the same opportunity for students to submit their questions. This activity also had a positive effect on the behavior of students in subsequent

meetings, as they became accustomed to formulating questions and eventually became more willing to ask questions without the lecturer prompting them.

The warm-up phase allowed students to read literature so that they were better prepared to participate in learning, were more active in asking questions, had the courage to respond to questions and arguments, and possessed critical reading skills. In this phase, students' readiness to participate in the learning process was enhanced. The students were instructed to utilize their existing knowledge so that they could demonstrate their learning with greater assurance. This phase made learning not only dominated by students with exceptional academic skills, but also by all students in the class. Students who were prepared to learn during the warm-up phase were more likely to be engaged during the exploring phase. Typically, learners who are trained to think critically have rational and reflective thinking processes that are centered on deciding what to believe or do. Strong critical thinking skills can be advantageous in all facets of life, including in achieving better learning outcomes [3].

The exploring phase offered students opportunities to exercise critical thinking when conducting scientific investigations. In this phase, students were taught how to gather the necessary information for the problem-solving process. The students were instructed to be able to link the knowledge gained from reading activities to exploration activities. In order for students to meet the course's learning objectives, they were also instructed to hone their reasoning skills and develop their analytical thinking in the construction of knowledge and comprehension. In the problem-solving process, students were also trained to build skills and social relationships with their peers. To maximize each other's potential in meeting learning requirements, the ability to work together, collaborate, and elaborate is essential.

During the exploring phase, the lecturer also provided scaffolding to students who have difficulty in doing scientific investigations and problem-solving, both individually and in groups. Critical thinking can facilitate the learning process and students' thinking. Higher order thinking skills play an important role in the cognitive development of learners [32], [33] conclude that the critical and creative character of students is reflected in the components of critical thinking and critical thinking skills that integrate four abilities, namely the ability to construct ideas, conduct reflective assessments, self-regulate, and recognize traits and behaviors.

At the outset of its implementation in the classroom, the exploring phase posed a challenge for the lecturer because students lacked sufficient learning independence. Therefore, the lecturer gave students clear instructions and explanations. The instructor also instructed the students to use their smartphones to access the internet if they encountered any difficulties. Problem-solving-related material was designed to be easier to comprehend if students engaged in more discussion with their classmates. During the exploring phase, students were trained to develop reasoning, critical-creative thinking, and collaboration skills to achieve group learning success. Critical thinking enables individuals to effectively address diverse social, scientific, and practical issues [34].

The argumentation phase of the WE-Are learning model trained students' critical thinking skills in analyzing environmental problems. In the argumentation phase, the comprehension of the knowledge-concepts acquired in the exploration phase was discussed and presented. According to the observations, students needed more time to contribute to argumentative production. Students needed time to research the pertinent theoretical foundations to bolster their arguments. At the outset of the implementation of the WE-ARe model, students struggled to generate quality arguments. In general, the generated arguments lacked solid and supportive data backings. Occasionally, the presented arguments were lengthy but of poor quality. Therefore, the lecturer taught students how to construct persuasive arguments. The students were required to read extensively and critically and to take notes on significant things that could be used to support their arguments. They were instructed to bolster their arguments by citing relevant e-books and research articles. This activity was conducted to stimulate the students' capacity for assimilation and accommodation so that they may gradually develop higher order thinking skills. Critical thinking involves a variety of intellectual qualities, such as clarity, relevance, sufficiency, and consistency, among others [25]. They were required to read extensively and critically and to take notes on significant things that could be used to support their arguments. Students were instructed to bolster their arguments by citing relevant e-books and research articles. This activity was conducted to stimulate the students' capacity for assimilation and accommodation so that they may gradually develop higher order thinking skills. Critical thinking involves a variety of intellectual qualities, such as clarity, relevance, sufficiency, and consistency, among others (Fisher, 2001). Critical thinking also involves higher-order cognitive processes in analyzing information to generate new ideas [35].

Students practiced their critical analysis skills by summarizing lessons during the resume phase. Students were taught a variety of cognitive strategies to enhance their reasoning abilities, such as critical analysis of related research articles, highlighting important points in

reading, noting the essence of learning, creating concept maps to facilitate comprehension, and other techniques. In practice, the lecturer examined student learning difficulties by analyzing the results of the collected resumes. If there were still students who had trouble capturing information or writing the resume, the lecturer instructed them to record the learning process, including the argumentation phase, on their smartphones or laptops using a voice recording application. Students were able to build resumes with the help of recordings because they can be listened to repeatedly based on their learning needs. The phases of WE-Are learning model can stimulate the critical thinking skills of preservice biology teachers.

The ability to think critically is a fundamental skill that university students must possess in order to solve problems. Students who can think critically tend to perform well on learning tasks. Critical thinking is essential for comprehending and studying abstract scientific concepts, particularly in biology. The ability to think critically also helps students complete their assignments [36]. They can discover how learning concepts apply to real-world situations and how to apply prior knowledge in novel contexts [37]. External factors that can influence the critical thinking skills of students include educational paradigms, teaching approaches and methods, the nature of assessment, educator feedback, an emotionally supportive environment, and positive attitudes [38], [39].

Critical thinking enables individuals to effectively address diverse social, scientific, and practical issues [34]. Students' critical thinking skills are important because students with strong critical thinking skills can become critical consumers of science in responding to and following various scientific developments [40]. At the test of critical thinking skills, students were required to examine a variety of information and use it to solve problems. They were also required to identify a pattern or procedure whose truth value they determined [41]. When life problems become increasingly complex, each person must adapt and make the best decisions to deal with the circumstance [42].

Graduates who possess 21st century competencies must be equipped with higher order thinking skills, including critical thinking skills. Critical thinking can shape competitive human resources for the 21st century [43]. Critical and creative thinking is important to cultivate because it can improve the quality of human resources and help students develop a growth mindset, particularly in everyday life [44]. Developing critical thinking and problem-solving skills is the foundation of all necessary 21st century skills [45], [46].

CONCLUSION

Based on the research findings and data analysis, it was concluded that the WE-Are learning model had an effect on preservice biology teachers' critical thinking skills. The highest mean score on post-test was obtained by the experimental group (81.714), followed by the positive control group (66.9995), and the negative control group (33.858). It is anticipated that the results of this study will serve as a reference for biology education lecturers and other subject lecturers who wish to implement the WE-ARe learning model in the classroom to improve students' critical thinking skills. In addition, future research can try to implement the WE-ARe learning model at various educational levels.

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