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The Effectiveness of Field Learning Based on *M. reinwardt* Ecotourism in Improving the Critical Thinking Skills of Biology Education Students

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Abstract: The development of critical thinking skills is a strategic agenda in biology education, particularly in preparing prospective teachers capable of integrating scientific analysis with real ecological contexts. However, learning that remains oriented towards classrooms and limited laboratories has not fully strengthened students' evaluative and argumentative abilities. Field learning based on *M. reinwardt* ecotourism offers a contextual approach that places students in authentic observation and analysis situations. This study aims to test the effectiveness of ecotourism-based field learning in improving the critical thinking skills (CTS) of Biology Education students. The study used a quasi-experimental pretest–posttest control-group design. The experimental group implemented the Ecotourism-Based Field learning Model (EBFL) by studying the ecology and conservation of M. reinwardt in the Gunung Tunak and Kerandangan Nature Tourism Parks, while the control group followed a conventional laboratory practicum. The research instrument was a CTS test validated by experts, and the model's effectiveness was analysed using N-Gain and the Mann–Whitney test. The results showed a significant difference in CTS improvement between the experimental and control groups, as well as a substantive influence of field learning on higher-level cognitive achievement. These findings strengthen the development of an ecotourism-based contextual science learning model as a pedagogical innovation in the education of prospective biology teachers.

Keywords: Critical Thinking; Ecotourism; Field Learning; Megapodius.

Introduction

Developing critical thinking skills is a strategic agenda in biology education, particularly in preparing prospective teachers to integrate scientific analysis with real-world ecological contexts. This competency is part of the 21st-century skills needed to address increasingly dynamic social, economic, and environmental complexities [1-2]. In science education, critical thinking skills include the ability to analyze information, evaluate evidence, and make decisions based on rational considerations and scientific argumentation [3-4]. In Indonesia, findings from the National Assessment indicate that students' reasoning and higher-order thinking skills remain at a level that needs strengthening. This situation indicates a gap between curriculum demands and learning practices, which are still dominated by classroom-based approaches oriented toward knowledge transfer. Therefore, learning approaches that provide authentic, contextual learning experiences are needed [5-6].

Outdoor learning, or field trips, has long been identified as an approach capable of improving the quality of science learning. Field learning activities allow students to directly observe natural phenomena, thus encouraging deeper reflection and analysis [7]. Various studies have shown that experiential field learning can improve critical thinking skills and environmental awareness by directly involving students in the scientific investigation process [8-9]. Systematically planned outdoor field trips can foster critical thinking skills and environmental awareness by involving direct observation and reflection on ecological phenomena [10]. However, most of this research focuses on outdoor learning in general and has not specifically integrated an ecotourism approach as a learning context. Yet, ecotourism holds great potential as a learning resource because it combines aspects of conservation, environmental education, and direct experiences in nature [6].

Furthermore, empirical studies in science learning have found that outdoor learning models have a positive impact on students' thinking and problem-solving skills (e.g., outdoor learning in science), demonstrating an increase in CTS after implementing an outdoor approach [11]. However, most of these studies have not focused on learning contexts that incorporate ecotourism and species observation approaches as a basis for learning, including the potential use of bird communities as learning resources in biology education. Furthermore, there is limited quantitative research on the effectiveness of these learning models for students' critical thinking skills in Biology Education programs.

The main variables in this study are EBFL as the independent variable and students' CTS as the dependent variable. This learning model is operationalized as a series of field learning activities designed to integrate direct observation experiences in the habitat of the *M. reinwardt*, field data collection, and scientific reflection. CTS are measured through indicators of analysis, evaluation, interpretation, and inference in the context of observed biological phenomena. The theoretical framework of this study is experiential learning theory, which holds that direct

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experience in real environments strengthens the formation of scientific concepts and complex reasoning abilities, thereby significantly improving students' critical thinking skills.

Based on the description, the research question is: Is the ecotourism-based field-learning model effective in improving the CTS of Biology Education students? The purpose of this study is to empirically test the model's effectiveness using a quasi-experimental design. The proposed hypothesis is that CTS increases significantly among students participating in the ecotourism-based field practicum model compared to those in conventional learning.

Research Methods

This study employed a quasi-experimental design with a pretest–posttest control group. This design was used to assess the effectiveness of EBFL in improving the scientific literacy of prospective biology teacher students. This approach allowed for comparison of results between the experimental and control groups without complete random assignment.

The subjects were fifth-semester students of the Biology Education Study Program, Faculty of Teacher Training and Education, University of Mataram, enrolled in the Animal Ecology course. A total of 55 students were purposively selected and divided into two groups of 30 each. The experimental group participated in learning using the EBFL model through a study of the ecology and conservation of the *M. reinwardt* in a local ecotourism area, while the control group underwent conventional laboratory practicums with equivalent materials.

The main instrument in this study was a test of critical thinking skills, such as focusing questions, analyzing arguments, asking and answering clarifying questions, considering the credibility of information sources, conducting systematic observations, and drawing conclusions through deduction and induction. Furthermore, critical thinking skills include the ability to define terms accurately, identify the assumptions underlying a statement, consider various alternative actions, and engage in argumentative discussion with others in the process of scientific inquiry. These indicators are important components of the CTS framework, which is widely used in educational research to assess the ability to analyze, evaluate, and make rational decisions [3, 12]. Furthermore, critical thinking skills include the ability to define terms accurately, identify the assumptions underlying a statement, consider various alternative actions, and engage in argumentative discussion with others in the process of scientific inquiry.

Furthermore, to ensure the quality of the measurement instrument, the validity and reliability of the test items were analyzed using the Rasch model. This model is an approach in Item Response Theory that allows researchers to evaluate the suitability of test items, the difficulty of the items, and the consistency of respondents with the measurement instrument more objectively [13; 14]. The use of the Rasch model in educational research has been widely recommended because it can provide more accurate parameter estimates for assessing the quality of the instrument, including in the measurement of scientific literacy and higher-order thinking skills [15].

The research procedure included the preparation stage (device development and instrument validation), the pretest, the 4-week intervention, and the posttest. Data were collected using a mixed methods approach. Qualitative data included model characteristics, indicators of scientific literacy and critical thinking, attitudes, perceptions, and student responses. Quantitative data included scores for scientific literacy and critical thinking skills. Analysis was conducted sequentially: qualitative data were analyzed descriptively and interpretively, while quantitative data were analyzed using inferential statistics. Ability improvement was calculated using N-Gain based on the formula and categorized into high, medium, or low levels [16]. Statistical tests were conducted using SPSS version 16 at the 5% significance level, and student response data are presented as average percentages per item.

Results and Discussion

Observations of critical thinking skills (CBT) in this study include five main indicators with twelve sub-indicators. These indicators include: (1) focusing questions; (2) analyzing arguments; (3) asking and answering questions; (4) considering the credibility of sources or criteria; (5) observing and considering the results of observations; (6) making deductions and considering the results; (7) making inductions and considering the results; (8) making and determining the value of considerations in decision-making; (9) defining terms and considering definitions; (10) identifying assumptions; (11) determining a course of action; and (12) interacting with others. These indicators are components of critical thinking skills that emphasize an individual's ability to analyze arguments, evaluate evidence, draw logical conclusions, and make rational decisions based on accountable considerations [17-20]. This framework is widely used in educational research to examine the development of higher-order thinking skills among students and learners in the context of science learning and scientific problem-solving. A summary of the results of KBK measurements through written tests and observations in EBFL activities is presented in Table 1.

The results of the study indicate that implementing ecotourism-based field learning focused on the bioecology of M. reinwardt has a positive impact on the CTS of biology education students. Based on the pretest and posttest analyzes, the average CTS score of students in the experimental class increased significantly compared to the control class. The average pretest score of the experimental class was 33.60, increasing to 77.10 in the posttest with an N-gain value of 66.68%, which is categorized as quite effective. In contrast, the control class experienced an increase from 34.50 to 59.37 with an N-gain of 40.81%, which is categorized as less effective. The results of the Mann–Whitney test on the posttest scores showed a p-value of 0.017 (< 0.05), indicating a significant difference in the improvement in critical thinking skills between the two groups.

The improvement in CTS observed in the experimental class shows that learning through direct experience in the natural environment can encourage students to engage in higher-order thinking. Through field observations of the habitat and behavior of *M. reinwardt*, students can connect theoretical concepts with biological phenomena found in the field. Direct experience-based learning is at the core of experiential learning theory, which emphasizes that knowledge is formed through the transformation of experience[4]. Furthermore, field learning activities also encourage the development of scientific inquiry processes. Students do not merely receive information passively, but are involved in formulating research questions, collecting data, and critically evaluating the results of observations. This approach aligns with the principles of inquiry-based learning, which have been proven effective in improving students' critical thinking and scientific reasoning skills [21; 22].

Table 1. Pretest and Posttest Results, CTS, N-Gain of Experimental and Control Classes of Biology Students 2024

	Experimental Class				Control Class			
	Pretest	Posts	g	N-gain (%)	Pretest	Posts	g	N-gain (%)
ID	28	28	-	-	27	27	-	-
SUM	941	2159	1218	1867	966	1603	767	
Average	33.60	77.1	43.50	66.68	34.50	59.37	27.39	40.81
Biology Education	11.42	16.62	10.93	17.91	11.40	23.58	13.79	25.87
Max.	60.00	96	61.00	93.33	54.00	98.00	52.00	88.14
Min.	11.00	39.00	17.00	26.67	12.00	30.00	10.00	11.90
Var	130.37	276.3	119.49	320.77	129.96	555.88	190.25	669.19
Mann-Whitney Test Pretest Asymp. Sig. 0.743								
Mann-Whitney Posttest Asymp. Sig. 0.017								

Description Effectiveness Interpretation Criteria:
% N-Gain > 76 Effective, 56 - 75 Sufficient; 40 - 55 Insufficient, %g < 40 ineffective (Hake, R. 1998).

Analysis of critical thinking skill indicators showed significant improvement in several indicators in the experimental class, particularly in the ability to identify criteria for considering answers, apply scientific principles, and select solutions based on rational considerations. This demonstrates that fieldwork provides students with opportunities to develop scientific thinking processes through direct observation, data analysis, group discussions, and systematic conclusion-making. Such experiential and inquiry-based activities have been shown to promote critical engagement with information, collaborative learning, and evidence-based reasoning in higher education contexts [23-24]. In addition, experimental and field-based learning environments encourage students to formulate hypotheses, interpret data, evaluate alternative explanations, and reflect on findings, all of which are essential components of scientific and critical thinking [25]. In the context of higher education, critical thinking skills include the ability to analyze information, evaluate evidence, and make decisions based on logical arguments. These skills are widely recognized as higher-order cognitive abilities necessary for problem-solving, reasoning, and decision-making, as well as for interpreting and evaluating information in academic and real-world contexts [26].

Observations during the implementation of the learning process also showed that the indicators of determining an action and interacting with others were the most dominant aspects developed in students. This condition indicates that field practicum activities encourage students to make quick, accurate decisions based on field conditions. In addition, these activities require group collaboration so that students can exchange ideas, discuss, and collectively evaluate the results of observations. Previous research has shown that collaborative learning in field activities can improve CTS by enabling students to engage in scientific argumentation and problem-solving together [27].

The effectiveness of field learning in this study is also related to the contextual nature of learning. The use of the *M. reinwardt* as the study object provides an authentic learning experience because this species has unique ecological characteristics, particularly in its reproductive strategy, which utilizes heat from the decomposition of organic matter or geothermal heat to hatch eggs. This biological uniqueness provides students with opportunities to conduct direct scientific exploration, observe ecological phenomena, and develop their ability to interpret environmental data. Learning that utilizes the local environmental context has been shown to increase student engagement and strengthen the understanding of biological concepts more deeply [6,9].

Furthermore, the study results showed that, prior to fieldwork, most students had a relatively limited understanding of the bioecology of *M. reinwardt.* This was evident from students' initial perceptions, which indicated a lack of understanding of the ecological role of birds in the ecosystem and the characteristics of species with limited distribution. After participating in the fieldwork, students demonstrated greater understanding of birds' ecological functions and their potential for use in conservation-based ecotourism activities. This finding aligns with research which states that environment-based learning can improve students' ecological literacy and conservation awareness [8].

Besides enhancing CTS, ecotourism-based field learning also positively impacts students' learning motivation. Direct involvement in field-based scientific observations and investigations provides a more meaningful learning experience than classroom-based learning. Stated that field-based learning activities can increase student engagement, knowledge retention, and curiosity about the scientific phenomena being studied [7].

The implementation of field learning also demonstrated the development of students' scientific reasoning skills. Improvements in several critical thinking indicators, such as the ability to identify problems, analyze arguments, and draw conclusions based on empirical evidence, indicate that the bioecological observation of the *M. reinwardt* encouraged students to critically interpret data. Students were exposed to various ecological phenomena that required them to examine the relationship between habitat conditions and the birds' reproductive behavior. This process fostered the development of reflective and analytical thinking skills, which are key components of critical thinking [3].

The fieldwork in this study also provided students with the opportunity to engage in hands-on scientific inquiry. Students not only received information from lecturers but also participated in formulating research questions, collecting field data, and discussing findings scientifically. This approach aligns with the principles of inquiry-based learning, which emphasize active student involvement in the knowledge construction process. Various studies have shown that inquiry-based learning can improve critical thinking skills by training students to evaluate evidence, test hypotheses, and construct logical scientific arguments [22-23].

Social interactions during fieldwork also contribute to the development of students' critical thinking skills. In group discussions, students exchange ideas, critique opinions, and construct arguments based on empirical data. This scientific dialogue process allows students to develop reflective thinking skills while broadening their perspectives on the ecological issues being studied. Research shows that collaborative learning can improve the quality of scientific argumentation and critical thinking skills by enabling students to negotiate meaning and evaluate ideas together [18,20].

Furthermore, ecotourism-based learning activities also positively impact students' environmental awareness and conservation attitudes. Through direct observation of the habitat and behavior of the *M. reinwardt*, students gain a deeper understanding of the importance of preserving ecosystems and biodiversity. Direct learning experiences in natural environments have been shown to significantly increase environmental literacy and pro-conservation behavior in students [8-9].

The findings of this study indicate that integrating field learning into the biology education curriculum can be an effective strategy for developing students' 21st-century competencies. Critical thinking, collaboration, communication, and problem-solving skills are essential competencies for prospective biology teachers to face the challenges of modern education. Therefore, implementing ecotourism-based learning that utilizes the potential of local biodiversity can be a relevant pedagogical innovation in higher education, particularly in biology teacher education programs.

Overall, the results of this study reinforce findings from several previous studies suggesting that experiential learning in the field is an effective approach to improving the quality of science learning. By providing students with the opportunity to directly engage in scientific investigations in natural settings, field learning not only enhances conceptual understanding but also develops critical thinking skills essential for scientific and professional practice in biology education [5-6].

Observations on the implementation of the EBFL indicate that most indicators of students' critical thinking skills developed predominantly during the field learning implementation phase. These indicators include the ability to focus questions, analyze arguments, ask and answer questions, consider the credibility of information sources, conduct observations, formulate deductions and inductions, and determine considerations in decision-making. The dominant pattern of these indicators indicates that the learning process involving direct field experience provides ample opportunities for students to develop higher-order thinking skills through authentic scientific activities. This condition is shown in Table 2.

Table 2. Observation Results of the Dominant Implementation of CTS in EBFL

KBK Indicator	Practical design	Design Presentation practical work	Implementation of activities practical work	Reporting and presentation of results, practical work	Evaluation & Conclusion
Focusing questions			√		
Analyzing arguments			√		
Asking, answering questions, and clarifying			√		
Consider credibility (source criteria)			√		
Observe and consider the results			√		
Make deductions & consider the results			√		
Making inductions & considering them			√		
make and determine the value of decision considerations			√		
Defining terms, considering definitions			√		
Creating and determining consideration values			√		
Determining an action		√	√	√	√

Description: √ = Dominantly developed by students

Based on the stages of learning activities, the observations in Table 2 indicate that students' CTS development does not occur in a single phase of the activity but rather occurs gradually throughout the field learning process. Each stage of the EBFL contributes differently to the development of indicators of students' critical thinking skills.

In the learning design stage, students begin to develop strategic thinking skills as they design field observation activities. At this stage, students identify problems, formulate observation objectives, and determine the data collection methods to be used. This planning process requires students to conduct an initial analysis of the ecological phenomena to be studied, so they can develop a systematic, logical activity plan. The ability to design a scientific investigation strategy is an essential part of CTS because it involves the process of analyzing problems and rationally planning solutions [3].

Next, in the presentation stage of the field learning plan, students demonstrate the development of the CTS indicators, especially in determining an action. At this stage, students present the activity plan they have prepared to other groups to obtain input and clarification. The discussion during the presentation allows students to critically evaluate the activity plan, consider alternative methods, and address weaknesses in the field research plan. Academic discussions such as these encourage students to develop scientific argumentation skills and to evaluate ideas logically. Research shows that discussion and presentation activities in project-based learning or scientific investigations can improve students' critical thinking skills through collective reflection and evaluation of ideas [4, 18].

The implementation phase of field learning activities is the most dominant phase in developing various indicators of student CTS. In this stage, students conduct direct observations of the bioecological phenomena of *M. reinwardt* in its natural habitat. This activity involves various scientific activities such as observing animal behavior, identifying habitat components, recording field data, and analyzing the relationship between biotic and abiotic factors. These activities encourage students to develop various CTS, such as focusing questions, analyzing arguments, considering the credibility of sources, and making deductions and inductions based on the empirical data obtained.

The dominance of critical thinking indicators at this implementation stage suggests that learning through direct experience in a natural environment provides a stronger cognitive stimulus than classroom lecture-based learning. Authentic learning experiences allow students to explore concepts more deeply and understand the relationship between theory and practice in the field. Field-based learning is a key component of experiential learning that can improve students' analytical and reflective abilities [5].

During the reporting and presentation phase of fieldwork, students further develop their CTS through data analysis and scientific report writing. Students must interpret the collected data, compare it with relevant theories, and develop scientific arguments to explain the observed phenomena. This process involves higher-order thinking skills such as evaluation, information synthesis, and drawing conclusions based on empirical evidence. Research shows that data analysis and scientific report writing can enhance CTS because students are trained to systematically organize information and construct arguments supported by data [6].

The final stage, evaluation and conclusion, also demonstrates the dominance of indicators determining action. At this stage, students reflect on the entire learning process and draw conclusions regarding observations of the bioecology of the *M. reinwardt*. This reflection process allows students to evaluate the effectiveness of the methods used and identify potential future research developments. Reflection is a crucial component of critical thinking because it helps students understand how decisions are made and how they can be improved in the future[8]. Furthermore, the dominance of indicators determining action at almost all learning stages indicates that the EBFL encourages students to become active and independent learners. Students not only passively follow lecturers' instructions but also participate in the decision-making process related to learning activities. This active engagement is a crucial characteristic of 21st-century learning, which emphasizes the development of critical thinking, problem-solving, and collaboration skills [8].

Overall, the observations in Table 2 indicate that the EBFL can facilitate the development of various indicators of student CTS through a systematic series of activities, from planning through evaluation of learning. The integration of field experiences with scientific analysis activities provides students with the opportunity to develop CTS comprehensively. Therefore, the application of this learning model can be an innovative alternative in biology education, particularly to improve learning quality through real-life experiences and the potential of local biodiversity.

Conclusion

The results of the study indicate that the application of EBFL in vertebrate zoology learning through the bioecological study of *M. reinwardt* is effective in improving the CTS of prospective biology teacher students. The increase in CTS in the experimental class was higher than the control class, with an N-gain value of 66.68% in the experimental class and 40.81% in the control class. The Mann–Whitney test also showed a significant difference between the two groups in the posttest. Field learning activities integrated with the ecotourism context provide authentic learning experiences through direct observation, analysis of ecological phenomena, and the development of scientific arguments based on empirical data. With a significant increase in the average score from 33.60 to 77.10 in the experimental class, EBFL can serve as an effective alternative learning model for developing students' CTS in biology, especially in the study of ecology and organism bioecology.

Author's Contribution

M. Yamin: responsible for conceptualization of the research, development of ecotourism-based field practice models, and implementation of the research. A. W. Jufri: played a role in academic supervision and review of the contents of the manuscript. Gunawan: contributed to data processing and analysis. A. Andriyan: supported in validation of research design and data visualization.

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