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Optimizing students' critical thinking skills through conservation-based ethno-inquiry practical guide

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ABSTRACT

This study aims to develop and produce a high-quality (valid, practical, and effective) ethno-inquiry practical guide to train students' critical thinking skills. This research is developmental and uses the R&D model. The teaching material developed was applied to 85 students from the Biology Education Department. The analysis of the practical guide's quality was conducted using average validity scores, Cronbach's alpha coefficient, paired t-test, N-gain, and ANOVA tests. The results show that the ethno-inquiry practical guide meets the following criteria: 1) valid based on content and construct validity reviews, 2) practical for use in learning, as indicated by excellent implementation of learning activities, and 3) effective in enhancing students' critical thinking skills with scores ranging from 0.40-0.52 (medium category). Based on student responses, the ethno-inquiry practical guide is categorized as good. This research implies that the practical guide can serve as an innovative solution to improve students' critical thinking skills.

INTRODUCTION

In the current era of the Fourth Industrial Revolution, various technological innovations such as robotics, artificial intelligence, nanotechnology, quantum computing, biotechnology, the Industrial Internet of Things (IIoT), and fifth-generation wireless technology have emerged (Latif, 2020). These innovations further spur the development of information technology, which facilitates the availability of big data that transcends spatial and temporal boundaries. The continuous development of information technology not only requires intellectual skills but also the ability to process and filter the massive flow of information. One of the essential skills needed to aid in the selection and proper use of information within the context of science and technology is critical thinking. The process of filtering information can only be done correctly and effectively by critical thinkers (Jamaluddin et al., 2020). Mastering critical thinking helps students sift through information that supports their success in life (Haeruddin et al., 2022)

Critical thinking skills are a competence that serves as a strong foundation for succeeding in both personal and professional life (Bezanilla et al., 2019). Critical thinking skills are related to the ability to evaluate, analyze, understand information, and creatively solve problems, thereby producing accurate judgments and decisions (Smith et al., 2018). Critical thinking is necessary to determine whether the information is valid or whether it should be accepted or rejected (Fitriani & Fibriana, 2020). Critical thinking activities involve a series of processes that encompass various steps to understand, evaluate, and respond to information critically (Facione, 2011; Wagner, 2015; Temel, 2022). Furthermore, critical thinking empowers individuals to take control of their understanding, enhances confidence, and fosters independent thinking (Sidiq et al., 2021). Thus, critical thinking is not just a skill but a core competency that helps individuals become lifelong learners and active participants in society, contributing to the creation of an intelligent and cultured nation.

Practical work can be an effective medium to optimize students' critical thinking skills. Practical activities are not only concerned with the result but also with how the thinking process can develop. Through practical learning, students are stimulated to solve problems actively, think analytically about issues based on existing facts, and discover concepts and principles, resulting in meaningful learning experiences. Practical activities can support students in developing both practical and cognitive skills (hands-on and minds-on) (Kurbanoğlu & Takunyacı, 2017). Practical work provides opportunities for students to develop logical thinking skills (Haryono & Adam, 2021). Similarly, practical activities allow students to encounter challenges and situations that require them to make decisions or develop solutions using environmental thinking (Satmaka et al., 2023). Practical work offers students the opportunity to encounter real-world problems and seek solutions using their critical thinking skills. Practical activities that emphasize logical thinking and reasoning in problem-solving are an integral part of critical thinking.

There are several indications of how important it is to master critical analysis skills (Wale & Bishaw, 2020). However, improvements in students' thinking skills, particularly in critical thinking, remain limited both during their studies and after graduation (Fitriani et al., 2019; McLaughlin et al., 2014). Consequently, many university graduates face challenges in obtaining employment due to a lack of adequate thinking skills (Alsaleh, 2020). The low critical thinking skills among students are attributed to inappropriate teaching methods, non-conceptual learning, and ineffective and inefficient delivery of material (Kawuwung et al., 2023; Hanum et al., 2023). The content taught in schools has not touched on critical analysis, there is no specific training to cultivate critical thinking competence, and assessments do not focus on higher-order thinking, which is an essential part of thinking (Sudarmin, 2019). This empirical study is further supported by a preliminary study conducted in the Biology Laboratory at Undikma. Observations revealed that the learning process in the laboratory was equipped with manuals containing practical activities. However, the content of these manuals resembled cooking recipes, where all the information related to the practical work had been provided. This condition hampers students' ability to think critically as they lack the opportunity to explore information to solve problems since everything, they need for the practical work is already presented. One of the reasons for the low level of practical activities is the difficulty lecturers face in designing practical guides, which results in over-reliance on providing detailed information (Utami & Dewi, 2020). This type of learning process does not yet demonstrate critical thinking. Consequently, students' critical thinking skills become stagnant and difficult to develop (Wayudi et al., 2020). This issue needs to be addressed immediately as it will affect the quality of graduates and students' preparedness to face challenges in the workplace.

One approach to solving the above challenges is inquiry-based learning, which can facilitate students in optimizing their critical thinking skills (Firdaus & Wilujeng, 2018; Mahanani et al., 2019; Kawuwung et al.; Falentina, 2021). Inquiry-based learning requires students to actively build knowledge, make reasoning, compare new concepts with initial ones, and connect that knowledge to find the best solutions (Putra et al., 2018). Inquiry learning emphasizes problem identification (Nisa et al., 2018; Maryam, 2020). The identification process involves empowering the thinking process (Hadi et al., 2018). Furthermore, dealing with complex problems requires a critical analysis of existing information (Dewi et al., 2019). Thus, students will be trained to evaluate information, construct arguments, and make decisions based on rational thinking. In this context, *ethno-inquiry* plays a crucial role by integrating cultural perspectives into inquiry-based learning. *Ethno-inquiry* is an approach that combines inquiry methods with the exploration of local values, traditions, and practices, helping students verify their understanding through investigative activities relevant to their cultural context.

To facilitate inquiry-based practical work, manuals are needed to guide students in preparing for practical activities so that the work is directed and systematic. Manuals are commonly used as learning resources in the learning process. Practical guides help students plan practical activities to be carried out systematically (Dewi et al., 2023). Training critical thinking through practical guides helps students develop analytical and evaluative skills related to practical material. These guides enhance students' understanding of scientific methods and inquiry-based learning. In the era of the Fourth Industrial Revolution, integrating local wisdom into learning materials is essential to balance scientific knowledge with cultural preservation. Studies show that incorporating local community values fosters meaningful learning and equips students with problem-solving skills (Dewi et al., 2021). The element of local wisdom as a pedagogical context can enhance students' achievement and learning motivation (Onwu et al., 2020). The use of local wisdom context in practical manuals can create a contextual learning process, stimulating students to think critically, actively, and creatively in an engaging atmosphere with easily understandable concepts, which in turn influences their interest and academic performance (Deda et al., 2021).

The Sasak people on Lombok Island possess a rich cultural diversity that can be integrated into learning content, including local knowledge, traditions, the use of local resources, and regulations aimed at ecosystem preservation (Arifin et al., 2024a). Dewi et al (2021) explain the importance of integrating traditional ecological knowledge with modern science into the educational curriculum. The relevance of this topic arises from the fact that local wisdom values have been increasingly eroded due to the rapid pace of globalization, highlighting the need for their integration into education to ensure their preservation. Local wisdom values have increasingly declined due to the rapid pace of globalization (Arifin et al., 2024b). One example of this is the erosion of cultural values and the neglect of local wisdom, where the ecosystem's function has been lost due to excessive exploitation of natural resources. These environmental issues reflect society's inability to develop environmental awareness, which is an integral part of local wisdom values. The degradation of the environment can be mitigated by controlling human behavior and managing the environment through cultural practices that have been proven to maintain ecological balance. One of the strategies to enhance students' critical thinking skills is integrating traditional conservation knowledge into the learning process. By engaging with these practices, students are encouraged to analyze, evaluate, and reflect on conservation efforts within the context of local wisdom, fostering their ability to think critically about environmental issues. This study emphasizes how traditional conservation practices can be used as an educational strategy oriented towards the development of critical thinking skills.

Based on the empirical studies and findings mentioned above, inquiry-based ethno-conservation practical manuals play a crucial role in supporting learning, particularly as innovative teaching materials that enhance students' reasoning abilities. Compared to conventional inquiry-based learning, which focuses primarily on scientific exploration, ethno-inquiry integrates local wisdom to provide a culturally relevant context for critical thinking development. Other methods, such as problem-based learning (PBL) and project-based learning (PjBL), also aim to improve critical thinking by engaging students in real-world problem-solving. However, inquiry-based ethno-conservation manuals offer a unique advantage by embedding cultural and environmental awareness into the learning process. Their implementation is expected to further optimize students' critical thinking skills. The research problem addressed in this study is to analyze the development of inquiry-based ethno-conservation practical manuals, specifically: 1) How valid are the inquiry-based ethno-conservation practical manuals in enhancing students' critical thinking skills? 2) How practical are the inquiry-based ethno-conservation practical manuals in improving students' critical thinking skills? 3) How effective are the inquiry-based ethno-conservation practical manuals in improving students' critical thinking skills?

METHODS

Research Design

This study employs a Research and Development (R&D) approach, specifically utilizing the 4D model. The main product qualifies as a practical guidebook aimed at enhancing students' critical thinking skills. This study is a pre-experimental study using a one group pretest-posttest design, namely 01x02 (Fraenkel, et al 2012).

Populations and Samples

This research was conducted at the Mandalika University of Education. The research sample comprised biology education students enrolled in the following courses: first-semester basic biology (Group 1), fifth-semester ecology (Group 2), and seventh-semester environmental impact. The sample was selected using purposive sampling, ensuring that participants met the criteria relevant to the study's objectives. Assessment (AMDAL) (Group 3).

Instrument

This research was conducted at the Mandalika University of Education. The research sample comprised biology education students enrolled in the following courses: first-semester basic biology (Group 1), fifth-semester ecology (Group 2), and seventh-semester environmental impact. The sample was selected using purposive sampling, ensuring that participants met the criteria relevant to the study's objectives. Assessment (AMDAL) (Group 3).

Procedure

The learning process began by administering a pre-test (01). Each student was asked to complete a critical thinking pre-test. Following the pre-test, the lectures provided training in critical thinking skills as initial preparation for the students before participating in the biology learning process. This training uses a guidebook for critical thinking practical exercises. Next, the lecturer implemented practical sessions in each group (X). The learning process concluded with a post-test (02). Each student was then asked to complete a critical thinking post-test, after which they were requested to fill out a student response questionnaire regarding the conducted learning.

Data Analysis Techniques

The validity of the practical guidebook was determined based on the assessment results, with the average validity score and Cronbach's alpha. The practicality of the guidebook was determined by referring to the assessment results with the average practicality score. The effectiveness of the practical guidebook was analyzed based on assessments made before and after using the conservation-oriented practical guidebook. The pre-test, post-test, and n-gain scores of students' critical thinking skills were further analyzed using inferential statistics. The choice of statistical testing method depended on whether the assumptions of normality and homogeneity were met. The n-gain was calculated using the equation: n-gain = (maximum score – pre-test score) / (4 – pre-test score) (Hake, 1998), with the following criteria: (1) if n-gain ≥ 0.70 (high), (2) if $0.30 <$ n-gain < 0.70 (medium), and (3) if n-gain ≤ 0.30 (low). The practicality of the practical guidebook was analyzed by reviewing the implementation of the learning process observed by two observers. The evaluation choices on the instrument consisted of not practical (score 0), less practical (score 1.00), sufficiently practical (score 2.00), practical (score 3.00), and highly practical (score 4.00). The practicality of the practical guidebook was determined by referring to the assessment results, with the average practicality score criteria as follows: 3.25 < highly practical ≤ 4.00; 2.50 < practical ≤ 3.25; 1.75 < less practical ≤ 2.50; and 1.00 ≤ not practical ≤ 1.75.

The effectiveness of the practical guidebook was analyzed based on assessments made before and after using the practical guidebook. The pre-test, post-test, and n-gain scores of students' critical thinking skills were further analyzed using inferential statistics with the assistance of SPSS software. The choice of statistical testing method depended on the assumptions of normality and homogeneity of the variance in pre-test, post-test, and n-gain environmental literacy scores. Statistical testing used the Paired t-test/Wilcoxon test and the consistency analysis of n-gain across all groups after using the practical guidebook, applying ANOVA/Kruskal-Wallis tests. To assess student responses, the response data were analyzed using qualitative descriptive analysis (Novitasari et al., 2018), with the following criteria: (1) response ≥ 75% (very positive); (2) 50% ≤ response < 75% (positive); (3) 25% ≤ response < 50% (less positive); and (4) response < 25% (not positive).

RESULTS AND DISCUSSION

Validity of the Practical Guidebook

Three experts validated the developed practical guidebook during a Focus Group Discussion (FGD). The experts in the FGD consisted of one learning media expert, one biodiversity content expert, and one assessment instrument expert. The results of the quality assessment of the practical guidebook are presented in Table 1. Table 1 shows that the validity of the practical guidebook includes (1) content feasibility components, (2) language components, and (3) presentation components, with average scores ranging from 4 to 3, classified as very valid and valid, while the reliability of each content validity component is also dependable.

Table 1.
Average Validity of the Laboratory Manual.

Component	Validity and Reliability of the Laboratory Manual			
	Value	**Validity**	**α**	**Reliability**
Content Appropriateness Component				
A. Component of Critical Thinking				
1. Analyzing information	3.60	Very Valid	0.97	Reliable
2. Evaluating sources of information	4.00	Very Valid	1.00	Reliable
3. Assessing information objectively	4.00	Very Valid	1.00	Reliable
4. Problem solving	4.00	Very Valid	1.00	Reliable
5. Asking questions	3.00	Valid	0.97	Reliable
6. Formulating clear arguments	4.00	Very Valid	1.00	Reliable
B. Component of Content				
1. Content linked to real-life situations	3.60	Very Valid	0.96	Reliable
2. Encourages writing relevant theories	3.00	Valid	0.85	Reliable
3. Encourages understanding and mastering necessary concepts in the lab	3.60	Very Valid	0.97	Reliable
C. Component of Laboratory Tools and Materials				
1. Encourages recognition of laboratory tools and their functions.	3.60	Very Valid	0.98	Reliable
2. Encourages recognition of laboratory materials.	3.60	Very Valid	0.98	Reliable
Component of Language				
1. Suitability with students' developmental level	3.60	Very Valid	0.98	Reliable
2. Accuracy of grammar and spelling	4.00	Very Valid	1.00	Reliable
3. Easy to understand	4.00	Very Valid	1.00	Reliable
4. Illustrations align with the substance of the message	4.00	Very Valid	1.00	Reliable
5. Motivates students to respond to the message	3.00	Valid	0.98	Reliable
6. Encourage critical thinking	4.00	Very Valid	1.00	Reliable
7. Accuracy of sentence structure	3.60	Very Valid	0.97	Reliable
8. Consistency in using terms, symbols	3.60	Very Valid	0.95	Reliable
Component of Presentation				
1. Logical presentation	3.30	Valid	0.92	Reliable
2. Coherence of scientific procedures	3.60	Very Valid	0.97	Reliable
3. Motivates learning	3.30	Valid	0.92	Reliable
4. Student involvement and student-centered approach	3.60	Very Valid	0.98	Reliable

Based on the description of Table 1 above, it can be stated that the conservation-based ethno-inquiry practical guidebook has met the validity requirements to enhance students' critical thinking skills. The practical guidebook can be implemented in the learning process. The practicality of practical activities assisted by the conservation-based ethno-inquiry practical guidebook is evident from the implementation of the guidebook in learning activities.

The practicality of the practical guidebook refers to the level of implementation of practical activities using the developed guidebook, as observed using an observation sheet instrument for learning implementation by three observers. Observations on the implementation of learning were carried out in three groups. The results of the analysis of the overall implementation of learning can be summarized in Table 2.

Table 2.
Implementation of ethno inquiry-based lab manuals

Phase	Group-1			Group-2			Group-3		
	S	**C**	**r**	**S**	**C**	**r**	**S**	**C**	**r**
1	3.75	VP	R	3.62	VP	R	3.75	VP	R
2	3.73	VP	R	3.69	VP	R	3.67	VP	R
3	3.64	VP	R	3.85	VP	R	3.60	VP	R
4	3.87	VP	R	3.68	VP	R	3.87	VP	R
5	3.62	VP	R	3.91	VP	R	3.75	VP	R

Note: S (score); C (criteria); VP (very practical); r (reliability); R (reliable); Phase 1 (problem orientation); Phase 2 (hypothesis formulation); Phase 3 (exploration); Phase 4 (hypothesis testing); Phase 5 (drawing conclusions).

Based on the data in Table 2, it can be stated that each phase/step of inquiry during the practicum activities and the observed aspects consist of 1) the practicum syntax, which includes problem orientation, problem formulation, hypothesis development, exploration, hypothesis testing, and conclusion drawing, 2) classroom management, and 3) classroom atmosphere, with the average score of each group falling within the "very good" category. Three different observers conducted observations on the practicality of implementing the conservation-based ethno-inquiry practicum guidebook; thus, the reliability of each phase needs to be accounted for. Table 2 illustrates that all the learning steps used can be implemented very well and reliably (meeting the practicality criteria).

Effectiveness of the Conservation-Based Ethno-Inquiry Practicum Guidebook

The effectiveness of the ethno-inquiry-based practicum guidebook is presented in Tables 3, 4, 5, and 6, which will be explained as follows.

Table 3.
The average scores of pre-test, post-test and n-gain of critical thinking skill at all groups.

Group	N	Average scores pre-test, post-test and n-gain of critical thinking					
		Pre-test		**Post-test**		**N-gain**	
Group-1	40	1.49	Low	2.38	Moderate	0.35	Moderate
Group-2	28	1.53	Low	2.63	Moderate	0.44	Moderate
Group-3	17	1.26	Low	2.45	Moderate	0.43	Moderate

Table 3 depicts the average scores of students' critical thinking skills in the pre-test, post-test, and n-gain. In all groups, the average pre-test scores ranged from 1.26 to 1.53, which falls into the low category. This is because students still experienced significant difficulties and were not yet accustomed to applying critical thinking skills. These findings align with the results of the preliminary study, which showed that students' critical thinking skills were still relatively low. In contrast, after the implementation of the practicum using the conservation-based ethno-inquiry practicum guidebook, all groups successively achieved post-test scores of 2.38, 2.63, and 2.45, placing them in the medium category. Table 3 indicates that the n-gain of students' critical thinking skills in each group was 0.35, 0.44, and 0.43, also categorized as medium. These results demonstrate that the implementation of the conservation-based ethno-inquiry practicum guidebook has proven effective in improving students' critical thinking skills. The indicators of students' critical thinking skills for all groups are presented in

Table 4.

Table 4.
The critical thinking skill indicators for all groups.

Group		Indicators of critical thinking skill											
		PF		DMI		I		E		A		DE	
G1	O1	2.33	M	0.93	L	2.03	M	1.40	L	1.80	L	0.50	L
	O2	3.11	H	2.05	M	2.96	H	2.10	M	2.90	H	1.20	L
	<g>	0.46	M	0.36	M	0.47	M	0.26	L	0.50	M	0.20	L
G2	O1	2.00	M	0.90	L	2.40	M	1.50	L	1.90	L	0.50	L
	O2	3.00	H	2.40	M	3.10	H	2.50	H	3.00	H	1.80	M
	<g>	0.50	M	0.48	M	0.43	M	0.40	M	0.52	M	0.37	M
G3	O1	1.70	L	0.80	L	1.40	L	1.40	L	1.60	L	0.70	L
	O2	2.80	H	2.20	M	2.50	M	2.50	H	2.80	H	1.90	M
	<g>	0.47	M	0.43	M	0.42	M	0.42	M	0.50	M	0.36	M

Note: G1 (Group 1); G2 (Group 2); G3 (Group 3); PF (problem formulation); DMI (decision-making and implementation); I (induction); E (evaluation); A (argument); D (deduction); L (Low); M (Moderate); H (High).

Table 4 shows that all indicators of critical thinking skills in the pre-test were in the low category. In contrast, after the implementation of the conservation-based ethno-inquiry practicum guidebook, the results indicated an improvement in all critical thinking skill indicators. The n-gain for critical thinking skill indicators generally fell into the medium category, with scores ranging from 0.40 to 0.52. This improvement is attributed to the implementation of the practicum learning using the ethno-inquiry practicum guidebook, which was designed to enhance students' critical thinking skills.

The results of the normality and homogeneity variance tests indicate that the pre-test, post-test, and n-gain scores of students' critical thinking skills were homogeneous and normally distributed across all groups. Therefore, the impact of the conservation-based ethno-inquiry practicum guidebook on improving critical thinking skills across all groups was tested using the Paired t-test, and consistency was examined using ANOVA. The results of the Paired t-test and ANOVA are presented in Tables 5 and 6.

Table 5.
The results of the Paired t-test of critical thinking skills at all groups.

Group	N	Paired t-test, α = 5%				Effect Size	
		Mean	t	df	p		
Group-1	40	-23.20	-24.04	29	.0000	4.38	Small
Group-2	28	-27.06	-17.46	29	.0000	3.18	Small
Group-3	17	-29.63	-24.61	29	.0000	4.55	Small

Table 5 shows the average critical thinking skills of groups 1, 2, and 3 were -23.20, -27.06, and -29.63, respectively, with t-values for each group of -24.04, -17.46, and -24.61. Each group had a significance value of $p < 0.05$, leading to the conclusion that the implementation of the conservation-based ethno-inquiry practicum guidebook had a significant effect on students' critical thinking skills. The effect size for groups 1, 2, and 3 was 4.38, 3.18, and 4.55, respectively, which falls into the small category.

Table 6.
The results of the ANOVA test of critical thinking skills in all groups.

ANOVA test, α = 5%	Sum of squares	df	Mean square	F	p
Between groups	512.04	2	256.02	4.056	.021
Within groups	5492.18	87	63.12		
Total	6004.22	89			

Table 6 shows that the calculated F value is F = 3.101, which is less than the F table value (4.056), with a significance level of $p = 0.021 < 0.05$. This clearly indicates that there is no significant difference in the improvement of students' critical thinking skills across all groups after the implementation of the conservation-based ethno-inquiry practicum guidebook.

Table 7.
The responses of preservice physics teachers in all groups.

Group I				Group II				Group III			
A	R	C	S	A	R	C	S	A	R	C	S
93.42%	98.34%	94.01%	93.54%	92.71%	97.81%	98.72%	93.90%	93.84%	97.24%	97.59%	92.06%

Note: A (attention); R (Relevance); C (confidence); S (satisfaction)

The results of student responses are presented in Table 7. The analysis of student responses to the learning process, which applied the conservation-based ethno-inquiry practical guide, was conducted by distributing student response sheets after the learning process. Table 7 shows that, in general, students provided very positive responses to the conservation-based ethno-inquiry practical guide, with satisfaction rates for each group ranging from 92.06% to 98.72% (very satisfied).

Validity of the Practical Guidebook

Referring to the data analysis results concerning the validity of the developed conservation-based ethno-inquiry practical guide, the following points will be discussed. The conservation-based ethno-inquiry practical guide was assessed in terms of content, language, and presentation feasibility. Generally, the average validity score fell into the good or appropriate category for use after revisions were made. Based on the work instructions contained in the practical guide, it can be said that the guide is capable of stimulating students to think critically.

The modifications made to the practical guide involved providing discussion sheets that had to be answered during the practical activities. The practical guide presented encourages students to engage in thinking activities. The presentation of this practical guide follows the rules set by Salirawati (2007), which emphasizes avoiding a "cookbook" format where the instructions are so complete that there is no room for students to think. A good practical guide contains steps for practical activities that demand student independence. In this guide, students are given questions as part of the practical activities, allowing them to hone their critical thinking skills. Through these activities, students are required to identify problems, make judgments or decisions on an issue, explain and interpret facts, analyze problems, express opinions, evaluate perspectives, and conclude problems based on facts. Through these tasks, students actively engage in observation, measurement, and data collection to conclude, and they can communicate with other students without being limited to following the exact steps outlined in the previous practical instructions. The lecturer's role is only as a facilitator, reviewing the implementation and results of the experiment. Hasmiati et al., (2017) explained that students who are given autonomy in practical activities tend to think more actively and discover insights about what they want to know.

The unique feature of the conservation-based, ethno-inquiry practical guide is its learning steps, which allow students to discover concepts. The inquiry steps are integrated with an ethnoscience approach, which raises conservation topics using the local wisdom of the Sasak tribe. Each step is systematically arranged based on the inquiry syntax. The guide also includes analytical questions containing critical thinking skill indicators, setting it apart from most other practical guides. Widyaningrum et al., (2020) concluded in their research that practical guides incorporating local wisdom can enhance learning meaning and contribute to instilling a love of culture.

The practicality of the conservation-based ethno-inquiry practical guide was evident in its application. Table 2 shows that all practical activities using the developed guide could be implemented very well and reliably (meeting practicality criteria). This indicates that the conservation-based ethno-inquiry practical guide meets the practicality aspect in enhancing students' critical thinking skills. Another positive result is the empirical validity, which shows that the practical guide is appropriate for improving students' critical thinking skills. These findings align with Barthelemy et al., (2015), who noted that teaching is essentially an effort by lecturers to help students acquire knowledge. This is consistent with the application results of the practical guide shown in Table 4, which demonstrates that the planned learning activities could be implemented very practically by the teacher. The practicality findings of the conservation-based ethno-inquiry practical guide are supported by Vygotsky's social constructivist theory, which has major implications, namely: 1) social learning, 2) Zone of Proximal Development (ZPD), and 3) scaffolding (Arends, 2012; Moreno, 2010; Slavin, 2011). The practicality of the conservation-based ethno-inquiry practical guide can be used to assess its effectiveness in improving students' critical thinking skills.

Effectiveness of the Conservation-Based Ethno-Inquiry Practicum Guidebook

The effectiveness of the conservation-based ethno-inquiry practical guide is presented in Tables 3, 4, 5, and 6, which will be discussed as follows. Table 3 depicts the average scores of pre-test, post-test, and n-gain of students' critical thinking skills. In all groups, the average pre-test score was 1.26 to 1.53 (low category). Generally, students answered questions that only met one or two criteria, meaning their initial critical thinking skills were still in the low category. Most students experienced difficulties, ranging from merely formulating problems identifying variables to organizing data. This indicates that students could not yet engage in systematic thinking. This may be due to the fact that students had not studied or practiced systematic thinking in previous sessions. Many students still struggle and are not yet accustomed to applying critical thinking skills. Several researchers have pointed out that the quality of education and critical thinking skills among Indonesian students is still relatively low (Kawuwung et al., 2023; Hanum et al., 2023; Putra & Maridi, 2018).

Another external factor that may have influenced the results of this study is the varying levels of students' prior experience in practical sessions. Some students may have previously engaged in inquiry-based or problem-solving-oriented practicums, allowing them to adapt more easily to the conservation-based ethno-inquiry approach. On the other hand, students with minimal prior exposure to structured practical activities may have encountered difficulties in following the critical thinking processes embedded in the guide. Previous research has indicated that students with extensive experience in inquiry-based learning tend to exhibit stronger analytical and decision-making skills (Yuliati et al., 2021). Therefore, differences in prior practical exposure should be considered as a potential variable affecting students' performance in this study.

By using the developed practical guide, students' mastery of critical thinking skills improved in all groups to the medium category. The increase in critical thinking skills was due to the implementation of inquiry, which included collaborative activities and facilitated individual thought processes. Furthermore, ideas or problems generated from the thinking process were further analyzed in group activities to arrive at solutions (Brailas et al., 2017). Through the inquiry learning model, students were able to develop their critical thinking processes by focusing on activities centered on problem-solving, ideas, and concepts to build new knowledge (Caraballo & Lyiscott, 2020). This is in line with Bruner's view that students' intellectual development progresses with biological-psychological maturity, learning experiences, and social environments (Mursali & Safnowandi, 2016). The improvement indicates that practical learning using the developed guide can train students' critical thinking mastery.

Additionally, the questions presented in the practical guide stimulate students to think actively. Critical thinking skills can be enhanced by paying attention to the characteristics and potential of students' learning environments. Parmin et al., (2019) suggested that cultural development in society can be incorporated into science teaching material development. Contextual learning profiles based on culture can enhance learning effectiveness and significantly impact learning activities (Rahmawati et al., 2019), making critical thinking more open to diversity and challenges presented (Alvarez et al., 2022).

Table 4 also shows that all indicators of students' critical thinking skills in the pre-test were in the low category. In contrast, after the learning process using the conservation-based ethno-inquiry practical guide, the results indicated that all indicators experienced an increase in n-gain scores of 0.20 to 0.52, or in the medium category. This research proves that the implementation of the conservation-based ethno-inquiry practical guide is effective in enhancing students' critical thinking skills. This is because the developed guide meets content and construct validity. This is supported by the findings (Plomp, 2013; Dewi et al., 2019) that tools meeting content and construct validity can enhance and achieve learning objectives. These positive results stem from the learning process using the practical guide, which was designed to enhance critical thinking skill indicators, including decision-making and execution, induction, argumentation, evaluation, and deduction. This is reinforced by research findings (Caraballo & Lyiscott, 2020) that students' critical thinking skills can be improved through the inquiry process, reflected in formulating a problem, formulating hypotheses, identifying variables, defining variables, designing experiments, collecting data, summarizing observations, conducting analysis, and drawing conclusions. This study is strengthened by John Dewey's view that the learning environment should become a laboratory for solving real-life problems (Arends, 2012). This is also supported by the top-down process, where students begin with complex problems to solve and then find solutions with the teacher's assistance (Slavin, 2012), in which students practice the necessary basic skills. This condition makes it easier for students to process concepts to be learned, allowing concepts to be more easily remembered. Table 5 explains the significant difference between the pre-test and post-test of students' critical thinking skills. Table 6 shows that there was no significant difference (consistency) in the improvement of students' critical thinking skills as a result of the implementation of the conservation-based ethno-inquiry practical guide. These research results are supported by theoretical and empirical studies that the practical guide used is based on the scientific approach design to enhance students' critical thinking skills, and the learning process is based on Bandura's modeling theory, supported by cognitive-social constructivist learning theory, cognitive learning theory, behavioral learning theory, and motivation learning theory (Arends, 2012; Moreno, 2010). Furthermore, the element of local wisdom as a pedagogical context can enhance students' academic achievement and motivation (Onwu et al., 2020). The critical thinking skills observed in this study included six indicators: problem formulation, decision-making and execution, induction, evaluation, argumentation, and deduction. The percentage of students' critical thinking ability indicators is presented in Table 4.

The problem formulation indicator increased by 0.46-0.50, which falls into the medium category. This shows that students could formulate problems well, supported by students' learning experience factors, which became evident when the teacher organized learning tasks related to the problem. At the problem orientation stage, the lecturer introduced the learning topic, and students conducted observations in the surrounding environment associated with environmental pollution phenomena. The lecturer asked students to propose potential problems arising from the observation results through group discussions. The observation stage aimed to facilitate students in designing problem-solving strategies (Nisa et al., 2018). Additionally, students were guided to formulate hypotheses to help them find accurate and relevant information. Through the problem formulation and hypothesis process, students' thinking develops through reasoning stages (Hadi et al., 2018).

The decision-making and execution indicator increased by 0.36-0.48, falling into the medium category. This is partly due to the students' habit of applying skills in new situations, where they were trained to provide alternative explanations and consider existing data and evidence to explore new situations. Students were taught to use previous information to ask questions, make decisions, and conduct experiments. They were given questions that directed them to problem-solving plans. The ability to design problem-solving scenarios well formed the basis for students to develop critical thinking skills. Through investigations, students gained experience and understanding of what they had learned. Teacher guidance was needed during the learning process. This shows that critical thinking skills began to grow and form through continuous practice. Critical thinking skills will develop well if appropriate learning is provided (Putra & Maridi, 2018; Özelçi & Çaliskan, 2019; Irwanto, 2023).

The induction indicator increased by 0.42-0.47, falling into the medium category. This indicates that students mastered the ability to conduct induction. Inductive reasoning is the process of concluding a series of specific observations or data, which are then used to draw general conclusions (Özelçi & Çaliskan, 2019). In inductive reasoning, students look for trends in observed data to draw more general conclusions. Inductive thinking emerges when students seek various information from observations and additional evidence sources to test its validity. Inductive thinking helps students evaluate information, understand arguments, and make decisions.

The argumentation indicator increased by 0.26-0.40, falling into the medium category. This shows that most students could analyze the truth of an argument, but the supporting reasons based on the data provided were not detailed enough. In this case, students still faced difficulties in providing opinions that expressed cause-and-effect relationships. To analyze data well, one needs the ability to connect existing concepts. According to Vygotsky, understanding is linked by connecting new knowledge with prior knowledge and constructing new meanings (Arends, 2012). Argumentation activities help students develop social skills, confidence, opinion-sharing abilities, and critical thinking while also helping them get to know one another (Dewi et al., 2019).

The evaluation indicator increased by 0.50, falling into the medium category. Through this evaluation indicator, students were already able to provide appropriate reasons for solving problems.

In addition, learning experience factors also played a role when the lecturer organized students to carry out investigations, assisted by a practical guide that led them to conduct proper evaluations in solving problems during learning.

The deduction indicator increased by 0.20-0.37, falling into the medium category. Students used inductive reasoning when constructing new knowledge based on their investigations. Knowledge deconstructed through scientific inquiry is beneficial for the development of science (Braillas et al., 2017). Subsequently, students gathered new knowledge from a series of thinking processes, such as conceptual framework design, data collection, hypothesis testing, data analysis, and evaluation. Inductive reasoning demonstrates students' intellectual level at the formal operational stage, where they begin to understand and use abstract principles. The key to critical thinking skills is when students can recall and understand knowledge logically based on prior knowledge (Shaughnessy et al., 2017).

The improvement in students' critical thinking skills was supported by the responses they provided. Table 7 shows that, in general, students gave positive responses to the conservation-based ethno-inquiry practical guide. To assess students' responses, a response questionnaire was used for the implementation of the conservation-based ethno-inquiry practical guide. The analysis results of student responses in three groups showed that overall, their responses to the developed guide were positive. The student response aspect refers to the motivation theory, including attention, relevance, confidence, and satisfaction (Keller, 2000). The attention response was in the positive category, meaning students were interested in learning using the practical guide. This was reinforced by the opinion of Trisna et al., (2018), stating that a conservation-based practical guide can increase students' appeal. In the relevance aspect, students gave a positive response, indicating that the developed learning method fostered a connection between learning activities and their benefits. The confidence aspect was also in the positive category, showing that the developed learning method helped build students' confidence. With confidence, students believe they can achieve effective goals through activities they perform independently. This aligns with the argument by Prahani et al., (2018) that when students believe that the problems studied are easy to solve, they will feel enthusiastic about solving them. The satisfaction aspect indicated that the developed learning method increased students' satisfaction with the learning process and outcomes. This satisfaction makes students more likely to repeat the learning process and outcomes. Overall, it can be concluded that students were interested in the learning process. Dewi et al. (2021) suggested that interest is one of the factors influencing learning outcomes. When someone is interested in an activity, it draws continuous attention and enjoyment, leading students to learn as best as they can because it appeals to them.

Overall, the responses obtained indicated that students felt their critical thinking skills had improved. This finding is supported by Bandura's modeling theory, which involves attention, where students must focus on the learning process; retention, where repetition is conducted so that procedural knowledge is easily remembered; production, where students need new problems to solve for knowledge internalization; and motivation, where further training fosters student motivation. Additionally, these findings show that the conservation-based ethno-inquiry practical guide significantly helped students understand the material, receive feedback, and make the learning process more active and enthusiastic. This is supported by Bahri & Destini (2020), who stated that positive student responses to learning supported by practical guides are the starting point for fostering students' enjoyment of learning, eliminating misconceptions, increasing student retention, and making the material easier to understand. Lecturers as facilitators need to allocate sufficient learning time so that students have the opportunity to discover, develop critical thinking skills, and build new understandings.

CONCLUSION

This study proves that the conservation-based ethno-inquiry practical guide meets the effectiveness criteria for improving the critical thinking skills of Biology Education Program students based on the following: (1) there was a statistically significant improvement in students' critical thinking skills before and after using the conservation-based ethno-inquiry practical guide at $\alpha = 5\%$; (2) the n-gain value of students' critical thinking skills was in the high/medium category; and (3) the average n-gain for students critical thinking skills in all groups was consistent. This research implies that the conservation-based ethno-inquiry practical guide can serve as an alternative to address the low level of students' critical thinking skills. To strengthen the results of this study, further research needs to be conducted across different educational levels.

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REFERENCES

Agnafia, D. N. (2019). Analisis kemampuan berpikir kritis siswa dalam pembelajaran biologi. Florea, *6*(1), 45-53. https://e-journal.unipma.ac.id/index.php/JF/article/view/4369

Alsaleh, N.J. (2020). Teaching Critical Thinking Skills: Literature Review. T*he Turkish Online Journal Educational Technology*, 19(1), 21-39. https://files.eric.ed.gov/fulltext/EJ1239945.pdf

Álvarez-Huerta, P., Muela, A., & Larrea, I. (2022). Disposition toward critical thinking and creative confidence beliefs in higher education students: The mediating role of openness to diversity and challenge. *Thinking Skills and Creativity*, *43*, 101003. https://doi.org/10.1016/j.tsc.2022.101003

Arends, R. I. (2012). *Learning to teach*. New York: Mc. Graw-Hill Companies.

Arifin, A. A., Ramdani, A., & Andayani, Y. (2024). Development of Learning Tools Based on the Culturally Responsive Transformative Teaching Model with a Socio-Scientific Issues Approach: Evaluation of Validity and Practicality. *Jurnal Penelitian Pendidikan IPA*, *10*(11), 9141-9155. https://doi.org/10.29303/jppipa.v10i11.9188

Arifin, A. A., Andayani, Y., & Sedijani, P. (2024). Rekonstruksi Etnosains Tradisi Pedak Api Masyarakat Narmada Dalam Pembelajaran Biologi. *Journal of Classroom Action Research*, *6*(1), 241-250. https://doi.org/10.29303/jcar.v6i2.6366

Bahri, S., & Destini, R. (2020). The Development of Teaching Materials Based on Student Worksheet Oriented to Inquiry Methods to improve student learning outcomes. *PalArch's Journal of Archaeology of Egypt/Egyptology*, *17*(3), 906-915. https://doi.org/10.48080/jae.v17i3.193

Barthelemy, S. R., Van Dusen, V. B., & Henderson, C. (2015). Physics education research: A research subfield of physics with gender parity. *Physical Review Special Topics - Physics Education Research, 11*, 020107. https://doi.org/10.1103/PhysRevSTPER.11.020107

Brailas, A., Avani, S. M., Gkini, C., Deilogkou, M. A., Koskinas, K., & Alexias, G. (2017). Experiential learning in action: A collaborative inquiry. *The Qualitative Report*, *22*(1), 271–288. https://doi.org/10.46743/ 2160-3715/2017.2551

Bezanilla, M. J., Fernández-Nogueira, D., Poblete, M., & Galindo-Domínguez, H. (2019). Methodologies for teaching-learning critical thinking in higher education: The teacher's view. *Thinking skills and Creativity*, *33*, 100584. https://doi.org/10.1016/j.tsc.2019.100584

Caraballo, L., & Lyiscott, J. (2020). Collaborative inquiry: Youth, social action, and critical qualitative research. *Action Research*, *18*(2), 194–211. https://doi.org/10.1177/1476750317752819

Deda, Y. N., & Maifa, T. (2021). Development of student worksheets using the context of local wisdom on integers and fractions. *Jurnal Pendidikan Matematika*, *15*(1), 71-82. https://doi.org/10.22342/jpm.v.i.12824.71-82

Dewi, I. N., Utami, S. D., & Adawiyah, S. R. (2023). Student Literacy Skills Through The Implementation of Assisted by Student Worksheets Based on Local Wisdom" Bau Nyale". *Jurnal Kependidikan: Jurnal Hasil Penelitian dan Kajian Kepustakaan di Bidang Pendidikan, Pengajaran dan Pembelajaran*, *9*(4), 1374-1382. https://doi.org/10.33394/jk.v9i4.9518

Dewi, I. N., Dwi, U. S., Effendi, I., Ramdani, A., & Rohyani, I. S. (2021). The Effectiveness of Biology Learning-Local Genius Program of Mount Rinjani Area to Improve the Generic Skills. *International Journal of Instruction*, *14*(1), 265-282. https://eric.ed.gov/?id=EJ1282347

Dewi, I. N., Ibrahim, M., Poedjiastoeti, S., Prahani, B. K., Setiawan, D., & Sumarjan, S. (2019, February). Effectiveness of local wisdom integrated (LWI) learning model to improve scientific communication skills of junior high school students in science learning. In *Journal of Physics: Conference Series* (Vol. 1157, No. 2, p. 022014). IOP Publishing.

Facione. (2011). Critical Thinking: What it is and Why it Counts. *Insight Assessment*, (ISBN 13: 978-1-891557-07-1.), 1–28. https://www.law.uh.edu/blakely/advocacy-survey/Critical%20Thinking%20Skills.pdf

Falentina, A. R., Saptasari, M., & Indriwati, S. E. (2021). Keterampilan Berpikir Kritis melalui Penerapan Model Pembelajaran Inkuiri Terbimbing di Kelas XI IPA. *Jurnal Pendidikan: Teori, Penelitian, Dan Pengembangan*, *5*(10), 1397-1404. https://dx.doi.org/10.17977/jptpp.v5i10.14100

Firdaus, M., & Wilujeng, I. (2018). Developing students worksheet on guided inquiry to improve critical thinking skills and learning outcomes of students. *Jurnal Inovasi Pendidikan IPA*, *4*(1), 26-40. https://doi.org/10.21831/jipi.v4i1.5574

Fitriani, E. Y., & Fibriana, F. (2020). Analysis of Religious Characters and Logical Thinking Skills After Using Solar System Teaching Material Integrated with Islamic Science. *Journal of Innovation in Educational and Cultural Research*, 1(2), 69-76. https://doi.org/10.46843/jiecr.v1i2.7

Fitriani, H., Asy'ari, M., Zubaidah, S., & Susriyati, M. (2019). Exploring the Prospective Teacher Critical Thinking and Critical Analysis Skills. *Jurnal Pendidikan IPA Indonesia,* 8(3). https://doi.org/10.15294/jpii.v8i3.19434.

Fraenkel, J., Wallen, N., & Hyun, H. (2012). *How to design and evaluate research in education*. New York: McGraw-Hill.

Haeruddin, H., Elpisah, E., & Apriyanti, E. (2022). Penerapan Literasi Kritis Dalam Pembelajaran IPS Mahasiswa Kelas VII SMPN 6 Kepulauan Selayar. *Jurnal PAJAR (Pendidikan dan Pengajaran)*, *6*(6), 1647-1658. http://dx.doi.org/10.33578/pjr.v6i6.8699

Hadi, S. A., Susantini, E., & Agustini, R. (2018). Training of Students' Critical Thinking Skills through the implementation of a Modified Free Inquiry Model. *Journal of Physics: Conference Series*, *947*(1). https://doi.org/10.1088/1742-6596/947/1/012063

Hake, R. R. (1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. *American Journal of Physics, 66* (1), 64-74. https://doi.org/10.1119/1.18809

Hanum, L., Hasan, M., Pada, A. U. T., Rahmatan, H., Rahmayani, R. F. I., Elisa, E., & Yusrizal, Y. (2023). Development of Learning Devices Based on Ethnoscience Project Based Learning to Improve Students' Critical Thinking Skills. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, *11*(2), 288-305. https://doi.org/10.24815/jpsi.v11i2.28294

Haryono, A., & Adam, C. (2021). The Implementation of Mini-Research Project to Train Undergraduate Students' Scientific Writing and Communication Skills. *Journal of Biological Education Indonesia (Jurnal Pendidikan Biologi Indonesia)*, *7*(2), 159-170. https://eric.ed.gov/?id=EJ1308613

Hasmiati, H., Jamilah, J., & Mustami, M. K. (2017). Aktivitas dan hasil belajar mahasiswa pada pembelajaran pertumbuhan dan perkembangan dengan metode praktikum. *Jurnal Biotek*, *5*(1), 21-35. https://doi.org/10.24252/jb.v5i1.3444

Irwanto, I. (2023). Improving preservice chemistry teachers' critical thinking and science process skills using research-oriented collaborative inquiry learning. *JOTSE*, *13*(1), 23-35. https://eric.ed.gov/?id=EJ1391786

Jamaluddin, J., Jufri, A. W., Muhlis, M., & Bachtiar, I. (2020). Pengembangan instrumen keterampilan berpikir kritis pada pembelajaran IPA di SMP. *Jurnal Pijar Mipa*, *15*(1), 13-19. https://doi.org/10.29303/jpm.v15i1.1296

Kawuwung, F. R., Mamahit, J. A., & Jabari, N. (2023). Enhancing Students' Critical Thinking Skills: A Quasi-Experiment Study on Inquiry Learning Model. *Jurnal Pendidikan: Teori, Penelitian, dan Pengembangan*, *8*(4), 271-276. https://doi.org/10.29303/jppipa.v9i8.4258

Keller, J. M. (2009). *Motivational design for learning and performance: The ARCS model approach*. Springer Science & Business Media.

Kurbanoğlu, N. İ., & Takunyacı, M. (2017). Development and evaluation of an instrument measuring anxiety toward physics laboratory classes among university students. *Journal of Baltic Science Education*, *16*(4), 592. https://eric.ed.gov/?id=EJ1423806

Latif, S., Zou, Z., Idrees, Z., & Ahmad, J. (2020). A novel attack detection scheme for the industrial internet of things using a lightweight random neural network. *IEEE access*, *8*, 89337-89350

Mahanani, I., Rahayu, S., & Fajaroh, F. (2019). Pengaruh pembelajaran inkuiri berkonteks socioscientific-issues terhadap keterampilan berpikir kritis dan scientific explanation. *Jurnal*

Kependidikan, *3*(1), 53-68. http://dx.doi.org/10.21831/jk.v3i1.20972
Maryam, B., Sören, H., & Gunilla, L. (2020). Putting scaffolding into action: Preschool teachers' actions using interactive whiteboard. *Early Childhood Education Journal*, *48*, 79-92. https://doi.org/10.1007/s10643-019-00971-3
McLaughlin, J. E., Roth, M. T., Glatt, D.M., Gharkholonarehe, N., Davidson, C.A., Griffin, L.M., Esserman, D.A., & Mumper, R.J. (2014). The Flipped Classroom: A Course Redesign to Foster Learning and Engagement in a Health Professions School. Academic Medicine, 89(2), 236-243. https://doi.org/10.1097/ACM.0000000000000086
Moreno, R. (2010). *Educational psychology*. New Mexico. John Wiley & Sons.
Mursali, S., & Safnowandi, S. (2016). Pengembangan LKM Biologi Dasar Berorientasi Pembelajaran Inkuiri untuk Meningkatkan Keterampilan proses Sains Mahamahasiswa. *Bioscientist: Jurnal Ilmiah Biologi*, *4*(2), 56-62. https://doi.org/10.33394/bioscientist.v4i2.218
Nieveen, N., McKenney, S., & van. Akker. (2007). *Educational design research*. New York: Routledge.
Nisa, E. K., Koestiari, T., Habibbulloh, M., & Jatmiko, B. (2018). Effectiveness of guided inquiry learning model to improve students' critical thinking skills at senior high school. *Journal of Physics: Conference Series*, *997*(1). https://doi.org/10.1088/1742-6596/997/1/012049
Novitasari, Y., Adi, E. P., & Praherdhiono, H. (2018). Respons afektif pebelajar terhadap pemberian tugas pada pembelajaran blended. *JKTP: Jurnal Kajian Teknologi Pendidikan*, *1*(2), 85-94. https://core.ac.uk/reader/287323690
Onwu, G. O., & Mufundirwa, C. (2020). A two-eyed seeing context-based approach for incorporating indigenous knowledge into school science teaching. *African Journal of Research in Mathematics, Science and Technology Education*, *24*(2), 229-240. https://journals.co.za/doi/abs/10.1080/18117295.2020.1816700
Özelçi, S. Y., & Çaliskan, G. (2019). What Is Critical Thinking? A Longitudinal Study with Teacher Candidates. *International Journal of Evaluation and Research in Education*, *8*(3), 495-509. https://eric.ed.gov/?id=EJ1232299
Putra, B. K. B., Prayitno, B. A., & Maridi, M. (2018). The Effectiveness of Guided Inquiry and INSTAD towards Studentsâ€™ Critical Thinking Skills on Circulatory System Materials. *Jurnal Pendidikan IPA Indonesia*, *7*(4), 476-482. https://doi.org/10.15294/jpii.v7i4.14302
Plomp, T. (2013). Preparing education for the information society: The need for new knowledge and skills. *International Journal of Social Media and Interactive Learning Environments, 1* (1), 3-18. https://doi.org/10.1504/IJSMILE.2013.051651
Prahani, B. K., Suprapto, N., Lestari, N. A., Jauhariyah, M. N. R., Admoko, S., & Wahyuni, S. (2018, March). The effectiveness of collaborative problem based physics learning (CPBPL) model to improve student's self-confidence on physics learning. In *Journal of Physics: Conference Series* (Vol. 997, No. 1, p. 012008). IOP Publishing.
Rahmawati, S., Subali, B., & Sarwi, S. (2019). The Effect of Ethnoscience Based Contextual Learning Toward Students Learning Activity. *Journal of Primary Education*, *8*(2), 152-160. https://journal.unnes.ac.id/sju/jpe/article/view/25688
Salirawati, D. (2007). Teknik penyusunan modul pembelajaran. *Yogyakarta: Universitas Negeri Yogyakarta*.
Satmaka, A. A. M., Rohman, F., & Prabaningtyas, S. (2023). Validitas dan Efektivitas Petunjuk Praktikum Elektronik Keanekaragaman Hayati untuk Meningkatkan Keterampilan Berpikir Kritis Mahasiswa SMA. *Bioscientist: Jurnal Ilmiah Biologi*, *11*(2), 1743-1752. https://doi.org/10.33394/bioscientist.v11i2.10021
Shaughnessy, M. F., Varela, M., & Liu, Z. (2017). Critical Thinking in Science: What Are the Basics?. *World*, *4*(4). https://core.ac.uk/download/pdf/268085454.pdf
Slavin, R. E. (2011). *Educational psychology, theory and practice*. Boston: Pearson Education
Sidiq, Y., Ishartono, N., Desstya, A., Prayitno, H. J., Anif, S., & Hidayat, M. L. (2021). Improving elementary school students' critical thinking skill in science through hots-based science questions: A quasi-experimental study. *Jurnal Pendidikan IPA Indonesia*, *10*(3), 378-386. https://doi.org/10.15294/jpii.v10i3.30891
Smith, T. E., Rama, P. S., & Helms, J. R. (2018). Teaching critical thinking in a GE class: A flipped model. *Thinking Skills and Creativity*, *28*(February), 73–83. https://doi.org/10.1016/j.tsc.2018.02.010
Sudarmin, S., Zahro, L., Pujiastuti, S. E., Asyhar, R., Zaenuri, Z., & Rosita, A. (2019). The development of

PBL-based worksheets integrated with green chemistry and ethnoscience to improve students thinking skills. *Jurnal Pendidikan IPA Indonesia*, *8*(4), 492-499. https://doi.org/10.15294/jpii.v8i4.17546

Temel, H. (2022). *The Effect of Critical Thinking Course Carry Out with Distance Education on Critical Thinking Skills and Dispositions*. *9*(3), 792–808. https://orcid.org/0000-0003-4532-0529

Trisna, D. M., Ruyani, A., & Yennita, Y. (2018). Pengembangan Lembar Kerja Peserta Didik Untuk Menilai Kecenderungan Berperilaku Konservasi Kura-KurA. *Diklabio: Jurnal Pendidikan dan Pembelajaran Biologi*, *2*(2), 102-107. https://agris.fao.org/search/en/providers/122436/records/6474803479cbb2c2c1b8c660

Utami, S. D., & Dewi, I. N. (2020). Pengembangan Lembar Kerja Mahamahasiswa Berbasis Pemberdayaan Berpikir melalui Pertanyaan pada Mata Kuliah Pengetahuan Lingkungan. *Bioscientist: Jurnal Ilmiah Biologi*, *8*(2), 327-336. https://doi.org/10.33394/bioscientist.v8i2.3165

Parmin, P., & Fibriana, F. (2019). Prospective teachers' scientific literacy through ethnoscience learning integrated with the indigenous knowledge of people in the frontier, outermost, and least developed regions. *Jurnal Penelitian Dan Pembelajaran IPA*, *5*(2), 142-154. https://dx.doi.org/10.30870/jppi.v5i2.6257

Wagner, D. A. (2015). Learning and Literacy: A Research Agenda for Post-2015. *International Review of Education*, *61*(3), 327-341. https://link.springer.com/article/10.1007/s11159-014-9447-8

Wale, B. D., & Bishaw, K. S. (2020). Effects of using inquiry-based learning on EFL students thinking skills. *Asian-Pasific Journal of Second and Foreign Language Education*. https://doi.org/10/1186/s40862-020-00090-2

Wayudi, M., Suwatno, S., & Santoso, B. (2020). Kajian analisis keterampilan berpikir kritis mahasiswa sekolah menengah atas. *Jurnal Pendidikan Manajemen Perkantoran*, *5*(1), 67-82. https://doi.org/10.17509/jpm.v4i2.18008

Widyaningrum, R., & Prihastari, E. B. (2020). Student worksheet based on Surakarta's local wisdom in primary school: A preliminary research. In *International Journal of Science and Applied Science: Conference Series* (Vol. 4, No. 1, pp. 56-65). https://doi.org/10.20961/ijsascs.v4i1.49458

Yuliati, L., Yogismawati, F., Purwaningsih, E., & Affriyenni, Y. (2021, March). Concept acquisition and scientific literacy of physics within inquiry-based learning for STEM Education. In *Journal of Physics: Conference Series* (Vol. 1835, No. 1, p. 012012). IOP Publishing. https://doi:10.1088/1742-6596/1835/1/012012