The Learning Tools of Inquiry-Creative Integrated with Ethnoscience: Its Validity and Effectiveness in Training Prospective Physics Teachers' Critical Thinking

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Abstract. This study aimed to develop the learning tool of inquiry-creative integrated with ethnosciences and assess its validity and effectiveness in training prospective physics teachers' critical thinking (CT) skills. The learning tool developed and validated including lesson plan, learning materials, and CT assessment instruments. Validity was assessed in terms of content and construct validity. The validation of the learning tool involved three validators using a validation sheet instrument. Furthermore, the effectiveness of the learning tool was tested through an experiment using a one-group pre-post test design involving twenty-two prospective teachers at Mataram University, Indonesia. The validity data analysis results indicated that the developed learning tool is valid in terms of content and construct validity. The analysis of CT scores during the implementation of the learning tool in the classroom showed an increase in prospective teachers' CT scores from the pre-test (M = -0.233, SD = 0.307) to the post-test (M = 2.170, SD = 0.277), indicating a shift from not-critical to critical, with an n-gain score of 0.53 (moderate). Statistical analysis of the data indicated a significant difference between the CT scores in the pre-test and post-test of the experimental group ($F = 743.619$, $p < .001$, $\eta^2 = 0.947$). This confirmed the descriptive analysis results that the prospective teachers' CT scores increased from the pre-test to the post-test. Overall, the findings strongly indicate that the learning tool of inquiry-creative integrated with ethnosciences is effective in improving the CT skills of prospective physics teachers.

Keywords: Inquiry, Creative Learning, Ethnosciences, Critical Thinking.

1 Introduction

The attainment of critical thinking competencies in university education relies on various interventions and approaches [1,2]. One particular area of focus is on student-teacher candidates who play a crucial role in shaping future students' critical thinking abilities [3]. These candidates are seen as key contributors to the advancement of the learning and education system, specifically in teaching critical thinking skills to students [4]. However, the challenge of cultivating critical thinking competence in student teacher candidates persists [5], as previous research indicates unsatisfactory

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levels of critical thinking skills among prospective teachers [6]. It is believed that inadequate teaching methods employed by lecturers may be one of the factors contributing to this issue [7].

Fortunately, there are numerous opportunities for innovation to enhance students' critical thinking abilities. For instance, student-centered interactive multimode learning has proven effective [8], as well as inquiry-based activities [9], authentic problem solving [10,11], exploration using natural and technological resources [12,13,14], self-evaluative processes in learning [15], and the integration of scientific creativity within inquiry methods [16]. However, these pedagogical approaches primarily focus on connecting subject matter with learning models and often overlook broader sociocultural aspects. Consequently, students may encounter difficulties when applying their problem-solving skills in authentic real-life contexts, particularly with regard to sociocultural factors, leading to underdeveloped thinking abilities.

The importance of acknowledging students' engagement with their surrounding environment and community, rather than solely focusing on classroom materials, highlights the need for incorporating sociocultural elements into the learning process. It is crucial to recognize the significance of cultural diversity, social values, and local wisdom in nurturing students' critical thinking abilities. This approach aligns with the current educational trend, which emphasizes the internalization of cultural diversity, social values, and local wisdom [17]. The integration of scientific knowledge with cultural values and local wisdom is commonly referred to as ethnoscience [17].

Ethnoscience, which encompasses the knowledge and scientific enculturation that develops within society, can be explored within the context of modern scientific knowledge. Inquiry-based learning serves as a means to achieve the goals of science education [18,19]. Within the framework of ethnoscience, cultural traditions and local wisdom are inseparable from knowledge [20]. The investigation of ethnoscience, as society's original knowledge, is facilitated through inquiry processes, emphasizing scientific creativity to foster critical thinking. This type of learning enhances students' scientific literacy [21] and positively influences the development of logical thinking in science [22].

A novel learning model called the inquiry-creative learning model has emerged to promote critical thinking skills, emphasizing scientific creativity [16,23]. Previous research has demonstrated that incorporating creativity into learning optimizes students' thinking abilities [24]. Consequently, it is essential to establish a new framework that integrates creativity and scientific inquiry with ethnoscience to cultivate students' critical thinking effectively. This framework should be implemented through learning tools, which serve as support to accomplish the desired learning outcomes [25].

This study aimed to develop the learning tool of inquiry-creative integrated with ethnosciences and assess its validity and effectiveness in training the critical thinking (CT) skills of prospective physics teachers. Learning tools refer to a collection of strategies designed to facilitate the learning process and achieve specific objectives [26]. These tools typically include a syllabus, lesson plans, worksheets, and CT assessment instruments [27], along with handouts or instructional modules [28]. For this study, the learning tools developed consisted of lesson plans, learning materials or modules, and CT assessment instruments.

2 Methods

This research study focused on the learning tools development of inquiry-creative integrated with ethnoscience, with the aim of enhancing critical thinking skills among prospective physics teachers. To ensure the quality of the learning tools, they needed to meet the criteria of validity and effectiveness [29]. The primary objective of this research is to train critical thinking skills in future physics teachers.

The learning tools created for this purpose include lesson plans, learning materials, and assessment instruments for critical thinking (CT). The validation process involved three validators using a validation sheet to collect data. Content validity and construct validity were the two aspects assessed for the learning tools. Content validity ensures that all components of the tools align with the needs and current knowledge in the field. Construct validity ensures that the components of the tools are consistently interconnected [29]. Specifically, construct validity refers to the extent to which a theory defines the operationalization of a construct or concept [30]. In a more specific context, construct validity is associated with a conceptual framework built upon a theory [31]. For the test instrument, content validity was assessed based on three content domains: domain definition, domain representation, and domain relevance [32].

To evaluate the effectiveness of the learning tools, an experiment was conducted using a one-group pre-post test design involving 22 students who were prospective physics teachers at the University of Mataram. The effectiveness was analyzed by comparing the critical thinking skills of the students before and after using the learning tools. The quantitative validation scores for each statement item ranged from 1 to 5, with 5 being the highest score. Descriptive analysis was conducted to assess the validation results by averaging the scores for each validation aspect provided by the validators. The validity of the learning device was determined based on the range of scores and criteria, ranging from invalid to very valid [33].

In addition, essay tests were utilized to gather data on the student's critical thinking skills during the pre-test and post-test stages. The results were analyzed both descriptively and statistically, using test analysis of variance. The critical thinking scores were categorized into different criteria, ranging from not critical to very critical, following the guidelines established in previous studies [5]. The increase in critical thinking scores from the pre-test to the post-test was measured [34].

3 Results and Discussion

Indonesian cultural traditions embody a wealth of local wisdom, representing indigenous knowledge that holds scientific concepts worth exploring. Such exploration can lead to the development of an ethnoscience study, serving as a valuable learning resource for students. Consequently, a research project was conducted with the objective of creating the learning tool of inquiry-creative that incorporates ethnoscience principles, aiming to enhance the critical thinking skills of prospective physics teachers. To ensure the effectiveness of the learning tools, lesson plans, learning materials, and test instruments were developed and subjected to a validation process. Content validity and construct validity were assessed by three independent validators, with the summarized results presented in Table 1.

Table 1. Results of three validators' assessment of learning tools

Validation aspects		Min	Max	Mean	SE	SD	Criteria
Content	Lesson plans	4.000	4.333	4.167	0.096	0.167	Valid
	Learning matter	4.000	4.286	4.143	0.083	0.143	Valid
	CT test instruments	3.750	4.000	3.833	0.083	0.144	Valid
Construct	Lesson plan	4.125	4.375	4.250	0.072	0.125	Very valid
	Learning matter	4.000	4.125	4.042	0.042	0.072	Valid
	CT test instruments	3.667	3.667	3.667	0.000	0.000	Valid

In terms of content validity, the learning tools, including the lesson plan, learning materials, and CT assessment instruments, all possess valid criteria. The lesson plan serves as the initial standard for planning the learning process to achieve desired objectives [35]. To effectively develop critical thinking skills, it is crucial to ensure that lesson plans and all learning tools are well-prepared and valid, as they form the foundation for classroom implementation [15]. The assessment results for construct validity indicate that the lesson plan demonstrated highly valid criteria, while the learning materials and CT test both exhibited valid criteria. Construct validity is of utmost importance in the learning planning system as it relates to the development of the lesson plan. Without a high-quality and valid lesson plan from a construct perspective, the teacher's guidance in the learning process may become biased [36].

The readiness of teaching materials is a significant endeavor to foster students' critical thinking [10]. The validity of learning materials in terms of content lies in their ability to meet valid criteria, ensuring that each teaching material presented to students is valid [37]. Teaching materials form an integral part of the learning tools and serve as the foundation for knowledge acquisition [38]. Therefore, teaching materials must possess construct validity to ensure their effective implementation. The construct validity of teaching materials indicates the accuracy of facts based on theory, making the material worthy of learning [39]. Previous studies have shown that valid learning materials or modules significantly contribute to the effectiveness of training students' critical thinking skills [40].

The validity of the test instrument was determined by measuring the validity of its three content domains: domain definition, domain representation, and domain relevance [32]. The test instrument reflects various contexts, including the content domain aligning with the operational definition of critical thinking (domain definition), the correspondence of content with cognitive specifications in critical thinking (domain representation), the relevance of each item to the content domain covered in the teaching material (relevance domain), and the content domain reflecting a novel framework that represents critical thinking approaches. These aspects are instrumental in assessing the construct validity of the test instrument. Previous studies have demonstrated that the validity of the test instrument serves as a measure of students' critical thinking skills' accuracy [3].

Additionally, Table 2 presents the analysis results of CT skills for prospective physics teachers in relation to the effectiveness of the inquiry-creative learning model integrated with ethnoscience. Descriptive plots of CT scores can be found in Figure 1.

Table 2. Results of CT skills analysis

Testing group	N	Mean	SD	SE	CT criteria
Pre-test	22	-0.233	0.307	0.065	Not critical
Post-test	22	2.170	0.277	0.059	Critical

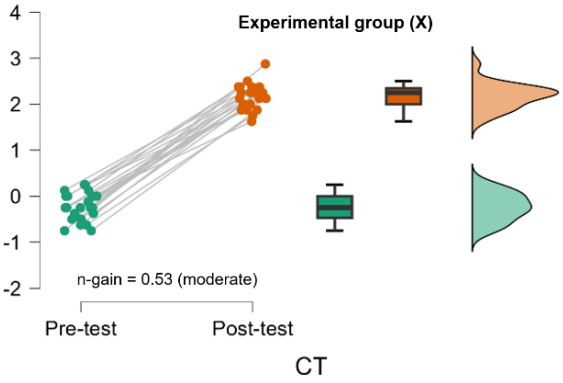

Fig. 1. Descriptive plot of CT scores in the pre- and post-test

The not-critical criterion was measured during the initial assessment (mean = -0.233, standard deviation = 0.307). Following the utilization of an inquiry-creative learning model combined with ethnoscience during the learning process, the post-test revealed an enhancement in critical thinking (CT) skill scores (mean = 2.170, standard deviation = 0.277). The increase in CT score could be considered as moderate (n-gain = 0.53). These findings suggest that the integration of the inquiry-creative learning with ethnoscience is an effective approach for enhancing students' CT skills. Additionally, an analysis of variance test was conducted to compare the pre-test and post-test scores, and the results are provided in Table 3.

Table 3. CT score analysis of variance test results (pre-test and post-test)

Cases	SS.	df	MS.	F	p	η^2
Within group (pre-test and post-test)	63.540	1	63.540	743.619	< .001	0.947
Residuals	3.589	42	0.085			

The test group exhibited a significant disparity in CT scores between the pre-test and post-test ($F = 743.619$, $p < .001$, $\eta^2 = 0.947$). These results support the descriptive analysis findings that CT scores tend to increase from the pre-test to the post-test. Consequently, it can be inferred that the learning tools of inquiry-creative integrated with ethnoscience have a noteworthy influence on enhancing CT skills. This outcome aligns with prior research, which suggested that intervention through scientific creativity in teaching inquiry can enhance analytical abilities among physics teacher candidates [41]. Additional studies even indicate that inquiry learning surpasses traditional teaching methods in enhancing students' thinking skills and learning outcomes [42].

The utilization of inquiry-creative learning integrated with ethnoscience benefits from the inclusion of scientific creativity. Scientific creativity in problem identification positively impacts students' CT skills [43]. Engaging in creative experiments strengthens process skills and scientific knowledge, ultimately influencing students' CT skills [44]. Students' execution of creative experiments enhances their capacity to achieve critical thinking [45]. Moreover, incorporating an ethno-scientific context complements the capacity of the learning process to enhance students' CT skills. Previous studies have demonstrated that the integration of ethnoscience into creative inquiry can effectively develop students' critical thinking abilities [46].

4 Conclusion

Extensive research has been conducted to develop the learning tool of inquiry-creative integrated with ethnosciences and assess its validity and effectiveness in training the CT skills of prospective physics teachers. In terms of content validity, all learning tools, including the lesson plan, learning materials, and CT assessment instruments, met the valid criteria. The assessment of construct validity revealed that the lesson plan had very valid criteria, while the learning materials and CT assessment instruments both met the valid criteria as well. An analysis of the CT results from the implementation of these learning tools in the classroom demonstrated a notable increase in CT scores from the pre-test to the post-test, indicating a shift from not-critical to critical thinking. Statistical analysis of the data further confirmed a significant difference between the CT scores of the test group in the pre-test and post-test. These findings support the descriptive analysis, highlighting the improvement in CT scores from the pre-test to the post-test. In conclusion, the findings strongly indicate that the learning tool of inquiry-creative integrated with ethnosciences is effective in improving the CT skills of prospective physics teachers.

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