The Validity and Effectiveness of the Ethnoscience-Loaded Inquiry Learning Model to Improve Students' Critical Thinking Skills

Saiful Prayogi[1], Sukainil Ahzan[1] , Indriaturrahmi[1] and
Joni Rokhmat[2]

[1] Mandalika University of Education, Mataram 83126, Indonesia
[2] University of Mataram, Mataram 83125, Indonesia
`saifulprayogi@undikma.ac.id`

Abstract. It's essential to establish a robust pedagogical framework to foster students with strong critical thinking skills. Current research is focused on creating an ethnoscience-loaded inquiry learning model to improve students' critical thinking skills, then authenticate the content and construct aspects while also evaluating its efficacy. This study aims to assess the validity and effectiveness of the ethnoscience-loaded inquiry learning model in improving students' critical thinking skills. This study was part of the research and development phase. The conceptual framework of the learning model was designed based on theoretical and empirical studies supporting the model. The learning model was then validated by five experts in terms of content and construct. The results indicated the learning model was highly valid in both aspects. Furthermore, the effectiveness of the learning model was tested through an experimental study using a one-group pre-post test design. In its implementation in the classroom, the ethnoscience-loaded inquiry learning model was delivered through a distance learning system in an e-learning platform. The study involves 27 students as participants. Essay tests were used as instruments to collect data on students' critical thinking skills. Descriptive analysis results show that the ethnoscience-loaded inquiry learning model can enhance students' critical thinking skills from a low level to a very high level. Statistical analysis strengthens the finding that there was a significant difference in students' critical thinking scores between the pre- and post-tests after implementing the learning model. These results indicate the ethnoscience-loaded inquiry learning model is effective in improving students' critical thinking skills.

Keywords: Ethnoscience, Inquiry Learning, Critical Thinking, Validity, effectiveness

1 Introduction

The development of critical thinking skills is closely tied to the quality of education within the classroom. When teaching practices effectively promote critical thinking and prioritize it as a learning outcome, students are more likely to achieve higher levels of critical thinking [1,2,3]. Consequently, implementing pedagogical strategies that are

proven to be effective can present an opportunity to enhance students' critical thinking performance [4]. It is important to encourage the modernization of innovative learning systems to better equip prospective teachers in nurturing critical thinking skills among their students [5,6,7]. Notably, the implementation of effective pedagogical strategies has been found to have a significant correlation with the improvement of students' critical thinking abilities [8]. In the context of science education, inquiry-based learning has long been recognized as a promising approach for cultivating students' thinking skills. Inquiry-based learning follows constructivist principles, positioning the teacher as a facilitator and encouraging active engagement from students [9,10,11].

Numerous studies have highlighted the potential of inquiry activities in cultivating critical thinking skills [12,13]. However, it is also important to acknowledge the limitations of inquiry learning. For instance, the process of exploring challenging concepts can prove difficult for students in terms of logical reasoning [14]. Moreover, the implementation of inquiry-based instruction faces obstacles due to students' inadequate initial knowledge [15]. Surprisingly, another study revealed that students' critical thinking habits were not influenced by the teacher's inquiry approach [16]. This finding raises questions about the difficulties encountered in previous studies regarding the training of critical thinking skills, such as inference [17] and evaluation [18], through the application of inquiry learning. Consequently, a novel framework is necessary to address this issue and effectively support students in enhancing their critical thinking performance.

The process of inquiry within the realm of science education is deeply intertwined with students' learning experiences within their environment and culture. It has been argued that the expression of scientific ideas is influenced by the local environment and culture [19]. To foster critical thinking, it is important to present authentic problem scenarios that reflect real-life situations, thereby connecting the learning process to the environment [20]. Developing critical thinking habits should be rooted in the social life, culture, local values, and customs of the students' surroundings, as this forms the foundation for introducing science education [21]. When science education incorporates the cultural traditions and local values of a nation, it is known as ethnoscience [22]. Integrating ethnoscience into learning not only enhances thinking skills but also nurtures a sense of national identity among students [23], leading to the development of positive character traits in their scientific pursuits.

Drawing on previous empirical research, the underlying justification posits that the incorporation of inquiry teaching design alongside ethnoscience can enhance students' aptitude for critical thinking [13]. The primary objective of our present investigation centers around constructing a conceptual framework for integrating ethnoscience content into inquiry-based learning, with the aim of improving students' critical thinking skills. Aspects of critical thinking skills are focused on analysis, inference, evaluation, and decision making [15]. Given that this learning model constitutes a novel framework, it is imperative to authenticate the content and structural aspects while also evaluating the efficacy of the developed model. This validation process is crucial to ensure that the learning model meets the criteria for being a comprehensive and high-quality educational product [24].

Specifically, the purpose of this study was to test the validity and effectiveness of the ethnoscience-loaded inquiry learning model in improving students' critical thinking skills. In its implementation in the class, the ethnoscience-loaded inquiry learning

model is packaged in a distance learning system on the e-learning platform. The novelty in this research is that inquiry learning is identified with exploring contexts related to ethnoscience and they are presented in a digital learning platform (e-learning).

2   Method

This study is part of development research [25], focused on designing the ethnoscience-loaded inquiry learning model to improve students' critical thinking skills. In this study, the conceptual framework was built based on a review of theoretical source studies and empirical studies, based on gathering information and literacy on relevant studies on ways to train students' critical thinking, the study of inquiry, and ethnoscience. The learning model that had been compiled was then validated by five validators on the content and construct aspects. The validators involved were those who have a Doctoral degree in science education, experience developing science learning models, and have experience teaching at universities as lecturers for ten years. Content validity was focused on two aspects, namely needs and state-of-the-art. Meanwhile, construct validity focuses on the consistent and logical aspects of the developed learning model.

Furthermore, testing the effectiveness of the learning model was carried out through experiments with one group pre-post test design. Simply put, this was through three processes, namely: pre-test (measurement of students' initial critical thinking abilities), treatment (implementation of learning models), and post-test (measurement of students' final critical thinking abilities). In its implementation, the inquiry learning model with ethnoscience is packaged in a distance learning system on the e-learning platform. The participants involved 27 students at the Mandalika University of Education. Learning was carried out in four meetings (not including the pre-post test), on the topic of Sound Waves.

Learning model validity data was collected using validation sheet instruments, and the results were analyzed descriptively. The validity of the learning model was categorized into five criteria, from invalid to very valid. The criteria and ranges of validity scores were: invalid ($x < 1.79$), less valid ($1.79 < x < 2.60$), quite valid ($2.60 < x < 3.40$), valid ($3.40 < x < 4.21$), and very valid ($x > 4.21$) [27]. Furthermore, the essay test was employed as an instrument to collect data on students' critical thinking skills. The test results were analyzed descriptively and categorized into criteria ranging from not critical to very critical. Calculation of score ranges follow the rules in previous studies [26,27]. Increasing critical thinking scores before and after learning treatment follows Hake's rules [28]. The standard for the effectiveness of the learning model is if it is able to improve students' critical thinking skills, with the final result (post-test) having critical criteria. Statistical analysis (paired t-test) was also employed to evaluate differences in pre- and post-test scores of students' critical thinking. The analysis tool used JASP-0.17.21 software.

3   Results and Discussion

In principle, the student learning experience with an ethnoscience-loaded inquiry learning model is to explore local cultural values related to science, and the problems

in it can be solved with scientific principles. This process becomes a process to encourage students to think critically. Comprehensively, the learning model framework is presented in Figure 1.
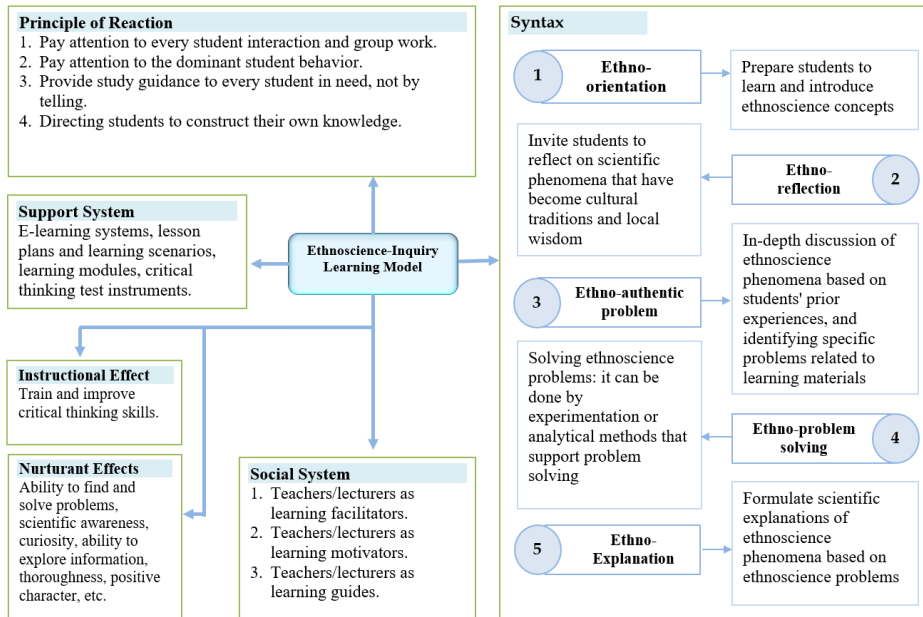

Fig. 1. The framework of ethnoscience-loaded inquiry learning model [29]

The ethnoscience-loaded inquiry learning model framework was compiled in a draft learning model document and then was validated. The results of the validation of the ethnoscience-laden inquiry learning model in terms of content and construct aspects are presented in Table 1.

Table 1. The results of the validation of the ethnoscience-loaded inquiry learning model

Aspects		Min	Max	Mean (SD)	SE	Criteria
Content validity	Needs	4.17	5.00	4.60 (±0.323)	0.144	Very valid
	State-of-the-art	4.20	5.00	4.64 (±0.297)	0.133	Very valid
Construct validity	Consistently & logically	4.25	5.00	4.60 (±0.335)	0.150	Very valid

The results of the validation in Table 1 show that the ethnoscience-loaded inquiry learning model was very valid theoretically in supporting students' critical thinking. A learning process requires a valid model design so that learning objectives can be achieved [30]. Specific to the purpose of critical thinking, previous studies [10,31] show that valid learning models in terms of content and construct validity have supported the achievement of teaching critical thinking to students. Furthermore, the developed model needs to be tested for its effectiveness in increasing students' critical thinking. Testing the effectiveness of the learning model was carried out through

experiments with a one group pre-post test design. The results are presented in Table 2, Figure 2, and Table 3.

Table 2. The results of the descriptive analysis of students' critical thinking skills

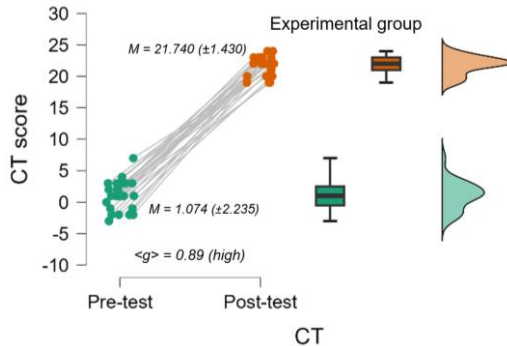| Tested group	N	Mean	SD	SE	Coeff. of var.	CT criteria
Pre-test	27	1.074	2.235	0.430	2.081	Less critical
Post-test	27	21.741	1.430	0.275	0.066	Very critical

Fig. 2. The results of the descriptive analysis of critical thinking skills in the raincloud plot

The results of the descriptive analysis as shown in Table 2 and Figure 2 show that students' critical thinking skills increased from not critical in the pre-test to very critical in the post-test. The increase in score, n-gain, was in the high category, $<g> = 0.89$. Furthermore, the results of statistical analysis (paired samples t-test) differences in critical thinking scores in the pre- and post-test are presented in Table 3. The data group tested met the normality assumption with the Shapiro-Wilk statistic = 0.965, and p = 0.482 (p > 0.05).

Table 3. The result of paired samples t -test

Paired Samples	t	df	p	Cohen's d	SE Cohen's d
Pretes-posttest	-37.786	26	< .001	-7.272	1.537

The results of the statistical analysis indicated that there was a significant difference in students' critical thinking scores in the pre- and post-test after the implementation of the learning model (t = -37.786, df = 26, p < .001). Combining descriptive and statistical findings, the ethnoscience-loaded inquiry learning model has been effective in improving students' critical thinking skills.

The success of applying inquiry in current studies was due to its integration with ethnoscientific contexts and the packaged in an e-learning framework. Its integration with ethnoscience makes inquiry learning more authentic [12], and the integration of inquiry within the e-learning framework makes it more interactive and interesting [32]. The framework of the ethnoscience-loaded inquiry learning model was identified with the process of reflection in the context of ethnoscience. Reflection on cultural values and local wisdom as an ethnoscience raised in inquiry experiments was a major factor

in the success of critical thinking training for students. As the results of previous study [13], the process of reflection in learning related to the ethnoscience context can train students' critical thinking skills.

Through the implementation of this learning model, students reflect on the principles of science in everyday life according to their cultural entity. The practice of reflection was important, where students have learning experience on how they carry out self-evaluations of each process and the way of thinking they do [33]. It is not only can train the thinking skills, other studies also reported that the practice of reflection has an impact on more meaningful deep learning [34]. Finally, a series of learning processes that employ an ethnoscience-loaded inquiry learning model have been convincingly effective in improving students' critical thinking skills.

4   Conclusion

A study has been conducted to test the validity and effectiveness of an ethnoscience-loaded inquiry learning model to improve students' critical thinking skills. The results indicate that in both aspects of validity (content and construct), the ethnoscience-loaded inquiry learning model is very valid. In its implementation, the inquiry learning model with ethnoscience can improve students' critical thinking skills from less critical (in the pre-test) to very critical (in the post-test). The results of the statistical analysis reinforce the finding that there is a significant difference between students' critical thinking scores in the pre- and post-tests after the implementation of the learning model. These results indicate that the ethnoscience-loaded inquiry learning model is effective in improving students' critical thinking skills.

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