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Inquiry-Creative Learning Integrated with Ethnoscience: Efforts to Encourage Prospective Science Teachers' Critical Thinking in Indonesia

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Abstract. Cultural entities and local or national wisdom can serve to provide scientific knowledge to students, and the in-depth knowledge in the fields of science must be underpinned by critical thinking (CT). In a developing perspective, inquiry is the best way to train CT skills, and creativity becomes one of the supporting aspects. This study aimed to implement inquiry-creative learning integrated with ethnoscience to develop the CT skills of prospective science teachers (PSTs). The study applied the randomized pretest-posttest control design, involving two intervention groups, one with inquiry-creative learning integrated with ethnoscience (n = 29) and the other with traditional teaching (n = 26). The participants were PSTs at two universities in Indonesia. Each group was observed for their CT skills in line with CT indicators (CTi) and individual performance (CTs) using the pretest-posttest method and compared, and a valid essay test was applied to collect data. The CT skills data analysis was descriptive based on the average pretest-posttest and n-gain parameters. The effects of the two interventions on CT skills were analyzed using the *t* test ($p < .05$). After descriptive and statistical tests were carried out, the assessment of CT performance on participants in the two intervention groups showed different results. For the CTi and CTs, inquiry-creative learning integrated with ethnoscience had a better

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impact on training participants' CT skills when compared to traditional instruction. The statistical analysis results showed a significant difference in the performance of CT skills in participants between the two groups being compared. The findings of this study emphasize that in relation to improving CT performance, teaching practice with inquiry-creative learning integrated with ethnoscience is most effective in improving the CT skills of PSTs. The advantages of the learning intervention are discussed and may contribute to the literature of future studies.

Keywords: critical thinking skills; ethnoscience; inquiry-creative learning; prospective science teachers; traditional teaching

1. Introduction

Science education reform is needed to prepare students for more brilliant future careers. It is related to the paradigm shift that was built from teaching to know to learning to think (Zoller & Nahum, 2012). In the end, the modernization of science education puts critical thinking (CT) in the top position as the most necessary skill (Bilad et al., 2022; Jang, 2016). CT is a cognitive activity to develop knowledge, understanding, and skills, and according to Bloom (1956), CT is a higher order thinking skill. CT skills are important to be taught because they allow learners to find the truth of information from phenomena or academic problems encountered (Suhirman et al., 2020). Unfortunately, most practical learning has not been oriented towards the attainment of CT skills (Bensley & Murtagh, 2012) because of differences in concepts in building CT skills, and components of CT (Moore, 2013). The worst thing is that even for a professional teacher, CT skills cannot always be taught properly (Phillips et al., 2011).

An important outcome expected in all forms of learning interventions at the higher education level is that students should be able to think critically (Tiruneh et al., 2017). This is especially true for prospective science teachers (PSTs) (Prayogi et al., 2018), because a professional teacher has a role as an agent of change for a better education system in terms of developing students' CT skills (Ma & Luo, 2021). In higher education institutions that produce science-teacher candidates, lecturers must train CT skills for prospective teachers, and the process during education before becoming a teacher is the right time for intervention activities that can train their CT skills (Verawati et al., 2021).

A recent teaching intervention with good potential to train CT skills is to apply a holistic learning process based on local wisdom (Sudarmin et al., 2019). This process has been adapted in the context of education in Indonesia. In line with the Indonesian National Higher Education Standards, the goal of training CT skills for students can thus be achieved by applying the characteristics of a holistic learning process that encourages the formation of a comprehensive and broad mindset by internalizing local or national wisdom and excellence (Dewi et al., 2019). It should be understood that science is a branch of knowledge that is based on natural phenomena, and the inquiry mode of teaching is used to attain the objectives of science learning (Aditomo & Klieme, 2020; Cheung et al., 2020). Inquiry in science is an enculturation process in which students participate in experimental communities in the classroom (Darling-Hammond et al., 2020; Kock et al., 2015). In practice, inquiry is understood as process-oriented learning to comprehend a concept theoretically only (Kock et al., 2013), and in the context of current learning, it is not in accordance with the characteristics of holistic learning. The holistic science-learning process is carried out by integrating and internalizing local and contextual wisdom (Suprapto et al., 2021).

Ethnoscience is the specialization of indigenous knowledge systems, where the ethnoscience looks at culture from a scientific perspective (Atran, 1991). Ethnoscience originated from the words *ethnos*, which means *nation,* and *scientia*, which means *knowledge*. Ethnoscience is seen as a system of knowledge and cognition typical of a given culture (Sturtevant, 1964). Ethnoscience is the integration of local wisdom and cultural values with scientific principles (Sudarmin et al., 2019). In the concept of ethnoscience, knowledge cannot be separated from local culture and traditions (Garcia et al., 2020). From birth, students are bound by the culture of life and nature before they go to formal education. Ethnoscience rooted in their lives is a form of contextual experiences (Parmin & Fibriana, 2019). Ethnoscience is balanced between the knowledge gained in the formal learning process in the class and the learning entities in their socio-cultural life (Arfianawati et al., 2016). Ethnoscience is a knowledge system that involves an explanation of nature. It has practical applications and is used for predictive purposes in learning (Wang, 2013) and to achieve the learning objectives themselves (Lestari & Fitriani, 2016).

Previous studies have shown that the integration of ethnoscience in learning can increase students' scientific literacy and CT ability (Seraphin, 2014), and affect them in logical and critical ways of thinking in science learning (Risdianto et al., 2020). The function of ethnoscience makes it easier for students to explore facts and phenomena in society, as it is integrated with science (Gunawan et al., 2019; Ramdani et al., 2021). However, the integration of learning with ethnoscience to optimize students' thinking skills has not been adequately studied (Sudarmin et al., 2019), so that practicing CT is still difficult for many teachers (van Peppen et al., 2021). The distressing thing is that the aspects of current learning practices are not holistic in that they do not integrate and internalize local wisdom (Suprapto et al., 2021). This is certainly a learning problem that should be resolved. CT is defined as reasonable and reflective thinking focused on deciding what to believe or do (Ennis, 2018). CT skills are very important for individuals, because it deals with their ways of solving problems effectively (Karantzas et al., 2013). CT skills cannot be trained arbitrarily; they must be honed with an appropriate pedagogical model intervention (Fitriani et al., 2022; Prayogi et al., 2018; Verawati et al., 2021; Wahyudi et al., 2019). CT can be practiced by presenting authentic problems in the surrounding environment and exploring them (Evendi et al., 2022). Authentic problems can be connected to experience and scientific knowledge in the cultural context in the environment where the individual or student grows and develops. Exploration of authentic problems related to ethnoscience is a process of training students in their CT skills.

Recently, inquiry learning has been modified by adding scientific creativity into its learning activities. This fusion has become well known as inquiry-creative learning (Wahyudi et al., 2018). When this is associated with science, scientific creativity is the hallmark of science learning in the class, and optimizing the quality of the students' creativity has an impact on many aspects of thinking (de Oliveira Biazus & Mahtari, 2022; Iskandar et al., 2020). Creative pedagogy cannot be separated from human life and contributes to students' success in the workplace (Prahani et al., 2021). As such, creative pedagogy must be implemented to support student success. Zainuddin et al. (2020) discussed routine learning that does not emphasize scientific creativity and fixates on traditional learning routines that hardly support changing learning. At the same time, students' knowledge construction and cognitive development can be attained through scientific investigations by optimizing creativity in experimenting (Suyidno et al., 2017). Prahani et al. (2021) highlighted the importance of creative pedagogy to train higher order thinking skills, because there is a relationship between the learning process conducted and the learning outcomes to be gained. To clarify this, literature has reported that when learning ignores scientific creativity, it is the same as traditional learning, with no expectation for any progress in learning performance (Zainuddin et al., 2020).

Practicing creative pedagogy in experimental models has been investigated, showing that it can train students in creativity and responsibility (Suyidno et al., 2019). However, to our best knowledge, creative pedagogy in the inquiry model has not been adequately studied in relation to improving CT performance. To attain a better perspective of CT skills, the present study integrates inquiry-creative learning with ethnoscience. The empirical framework in the current study is supported for several reasons. First, inquiry learning is designed with the aim of optimizing the quality of students' thinking (Arends, 2012), and several empirical studies have shown that inquiry has the potential to train the CT skills of PSTs (Ernita et al., 2021; Prayogi et al., 2018; Verawati et al., 2019, 2021). Second, the inquiry-creative process that is taught to PSTs has an impact on maintaining their CT skills (Wahyudi et al., 2019). Third, learning interventions that have the potential to train CT skills utilize a holistic learning process based on local wisdom, through ethnoscience (Sudarmin et al., 2019). Based on the review of related literature, the use of inquiry-creative learning integrated with ethnoscience has not been studied for the purpose of training the CT skills of PSTs. Therefore, the findings of this study might potentially contribute to the body of knowledge, especially related to classroom learning experiences, to support the CT performance of PSTs.

1.1 Research Aim

The specific aim of this study is to implement inquiry-creative learning integrated with ethnoscience and to evaluate its impact on the performance of PSTs in their CT skills. As a comparison, the study used a control group taught using traditional or expository teaching methods.

1.2 Research Variables
In line with the research aim, the following research variables are investigated in this study:
- The improvement of CT skills of PSTs by implementing inquiry-creative learning integrated with ethnoscience.
- The difference in increasing CT skills of PSTs between the two learning interventions (inquiry-creative learning integrated with ethnoscience vs. traditional teaching).

2. Methodology
2.1 Research Design
This study was an experimental study with a randomized pretest-posttest control design (Fraenkel et al., 2012). Two sample groups were formed based on the randomization scheme of the population, one as the experimental group (intervention group A) and one as the control group (intervention group B). Intervention group A was subjected to inquiry-creative learning integrated with ethnoscience (X_1), whereas intervention group B was subjected to traditional teaching (X_2). Each group was observed for their CT skills using a pretest (O_1) and a posttest (O_2). Below is the design adopted for this study:

Intervention group A	R	O_1	X_1	O_2
Intervention group B	R	O_1	X_2	O_2

To avoid bias between the groups, the implementation of learning was conducted by professional lecturers concurrently. Apart from the pretest and posttest, the number of learning sessions for each group were four.

2.2 Research Participants
The research participants were PSTs from the University of Mataram (Unram) and Mandalika University of Education (Undikma), Indonesia. The participants were randomly selected from the population of first-semester PSTs who were taking specialist courses in science at the universities. In all, 55 PSTs participated, of which 29 were in intervention group A and 26 were in intervention group B. The demographic characteristics of the participants based on gender and age are presented in Table 1.

Table 1. Demographic characteristics of the participants by gender and age

Characteristic		**Intervention group A (n = 29)**		**Intervention group B (n = 26)**	
		n	%	**n**	%
Gender	Male	15	52	13	50
	Female	14	48	13	50
Age (Years)	< 18	2	6.9	3	11.5
	18–19	24	82.8	22	84.6
	> 19	3	10.3	1	3.8

Within the scope of the research, and to involve humans as participants, permission was obtained from the Faculty of Teacher Training and Education –

University of Mataram, and the Institute for Research and Community Service – Mandalika University of Education.

2.3 Research Instruments and Data Collection

The research instruments for this study involved two aspects, learning tools and data collection instruments. The learning tools took the form of lesson plans and scenarios, learning modules, and worksheets, and were employed to support the implementation of inquiry-creative learning integrated with ethnoscience. The data collection instruments took the form of a CT skills test. Before being implemented in class, each instrument was validated by three validators. The validators were experts in science education and learning, had experience in science education research, and understood the context of inquiry and ethnoscience learning. The purpose with validation was to assess the feasibility of the learning instruments (learning tools and test instruments) before implementation. The learning tools and test instruments were assessed for validity in the aspects of content and construct validity using a validation sheet. Furthermore, each validator provided feedback on the validity of the learning tools and test instruments. The learning tools and CT skills test instruments were declared valid. Based on these results, the learning tools and test instruments could be employed to support the implementation of inquiry-creative learning integrated with ethnoscience.

Data on the CT skills of participants were collected using an essay test instrument. CT skills were assessed using four indicators: analysis, inferencing, evaluating, and decision-making. There were eight test items, with each indicator comprising two test items. Multi-level scoring (five scales) were used, according to Ennis and Weir (1985). We adapted the scoring criteria to range from 0 (lowest score) to +4 (highest score). The summary of the scoring rubric for each test item is shown in Table 2.

Table 2. Rubric for scoring CT skills for each test item

Descriptor	Score
1. No answer was provided.	0
2. The answer was incorrect, with incorrect arguments, not supported by facts, concepts, and laws.	+1
3. The answer was correct, but each CT indicator was not supported by strong arguments based on facts, concepts, and laws.	+2
4. The answer was correct, and each CT indicator was sufficiently supported by arguments based on facts, concepts, and laws.	+3
5. The answer was correct, and a strong argument supported each CT indicator with facts, concepts, and laws.	+4

CT skills data collection was carried out by administering valid test instruments to the participants of the two sample groups. The test was given at the beginning, before learning (pretest), and at the end, after learning (posttest). The test was administered to the two sample groups at the same time, and the time limit for answering the questions was 100 minutes.

2.4 Data Analysis

CT data were analyzed descriptively and statistically according to participants' CT performance parameters on the pretest and posttest for both intervention groups. CT data were computed in two main aspects: the CT performance for each indicator (CTi) and of each individual (CTs). Different calculations were used to determine CTi and CTs scores. To measure CTi, the min-max score range was 0 to +4. On the contrary, to measure CTs, the min-max individual score range was 0 to +32 (max score +4, multiplied by eight test items). The scoring criteria are summarized in Table 3. The score interval was adopted from a previous study (Prayogi et al., 2018), resulting in different score ranges for CTi and CTs.

Table 3. Score interval, CT skills score for each indicator (CTi) and each individual (CTs), and CT skills criteria

Score interval	Score interval of CTi	Score interval of CTs	Criterion
CT > Xi + 1.8 Sdi	CTi > 3.21	CTs > 25.60	Very critical
Xi + 0.6 Sdi < CT ≤ Xi + 1.8 Sdi	2.40 < CTi ≤ 3.21	19.20 < CTs ≤ 25.60	Critical
Xi - 0.6 Sdi < CT ≤ Xi + 0.6 Sdi	1.60 < CTi ≤ 2.40	12.80 < CTs ≤ 19.20	Quite critical
Xi - 1.8 Sdi < CT ≤ Xi - 0.6 Sdi	0.80 < CTi ≤ 1.60	6.41 < CTs ≤ 12.80	Less critical
CT ≤ Xi - 1.8 Sdi	CTi ≤ 0.80	CTs ≤ 6.41	Not critical

Note: Xi (ideal average) = ½ (max score + min score); Sdi (ideal deviation standard) = 1/6 (max score - min score)

Descriptively, the increase in CT skills scores on the pretest and posttest for both groups was analyzed using Hake's formulation (n-gain analysis) (Hake, 1999). The differences in CT scores of the two groups were statistically analyzed. The parametric statistical tests at least fulfilled the assumption of data normality ($p > .05$). The effects of the two learning interventions (X_1, X_2) on CT skills were analyzed using a paired *t* test, and the different effects of the two with an independent sample *t* test (n-gain parameters), each at $p < .05$.

3. Results

The results of the CTi analysis are summarized in Table 4. CTi was assessed for each group in line with the mean parameters of the pretest, posttest, and n-gain. Descriptively, the results in Table 4 show the variation in the scores of the four CT indicators.

Table 4. CTi measurement results based on the average parameters of the pretest, posttest, and n-gain

Group	n	Variable	CT skills indicator				Average
			AS	IF	EV	DM	
Intervention group A	29	Pretest	1.22	1.17	1.34	1.47	1.30
		Posttest	3.33	3.14	3.12	3.19	3.19
		n-gain	0.76 (High)	0.70 (Moderate)	0.67 (Moderate)	0.68 (Moderate)	0.70 (Moderate)
Intervention group B	26	Pretest	1.12	1.06	1.13	1.15	1.12
		Posttest	1.35	1.44	1.37	1.33	1.37
		n-gain	0.08 (Low)	0.13 (Low)	0.08 (Low)	0.06 (Low)	0.09 (Low)

Note: AS (analysis), IF (inferencing), EV (evaluation), DM (decision-making)

Based on the interventions, the pretest scores of participants were in the range of 0.80 < CTi ≤ 1.60. This means that the CT skills performance of participants according to the CT indicators was at the less critical level. In the posttest, the CTi scores of both groups increased. Intervention group A (inquiry-creative learning integrated with ethnoscience) acquired a CTi score which was higher than that of intervention group B (traditional teaching), with a posttest mean score range of 3.19 (critical, with 2.40 < CTi ≤ 3.21). Intervention group B achieved 1.37 (less critical, with 0.80 < CTi ≤ 1.60).
Figure 1 presents a visualization of the CTi results.

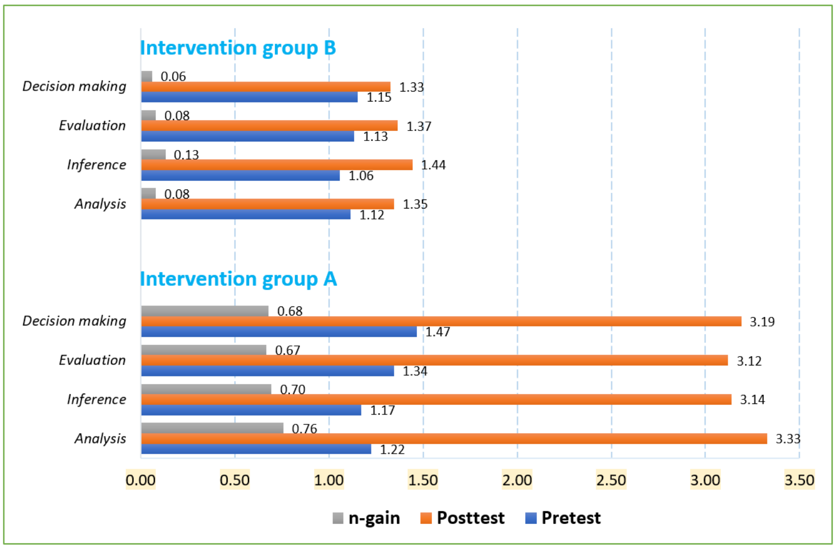

Figure 1. Comparison of CTi measurement results based on the average parameters of the pretest, posttest, and n-gain

The results in Figure 1 confirm the findings of this study. Intervention group A clearly achieved more superior CTi scores, with an increase in score (n-gain) of 0.71, whereas in group B, there was almost no increase in CTi. Furthermore, individual CT skills performance (CTs) was assessed, the results of which are summarized in Table 5.

Table 5. CTs measurement results based on the average parameters of the pretest, posttest, and n-gain

Group	n	CTs mean score and criteria				n-gain	Criterion
		Pretest	Criterion	Posttest	Criterion		
Intervention group A	29	10.41	Less critical	25.55	Critical	0.70	Moderate
Intervention group B	26	8.92	Less critical	10.96	Less critical	0.09	Low

Table 5 shows the mean CTs scores. The mean pretest score for intervention group A was 10.41 (less critical, with 6.41 < CTs ≤ 12.80), with the score increasing to a critical level, with a CTs score of 25.55 in the posttest (critical, with 19.20 < CTs ≤ 25.60). For intervention group B, participant scores remained on the less critical level for the pretest-posttest.

Differences in CTs measurement results for the two groups are shown in Figure 2.

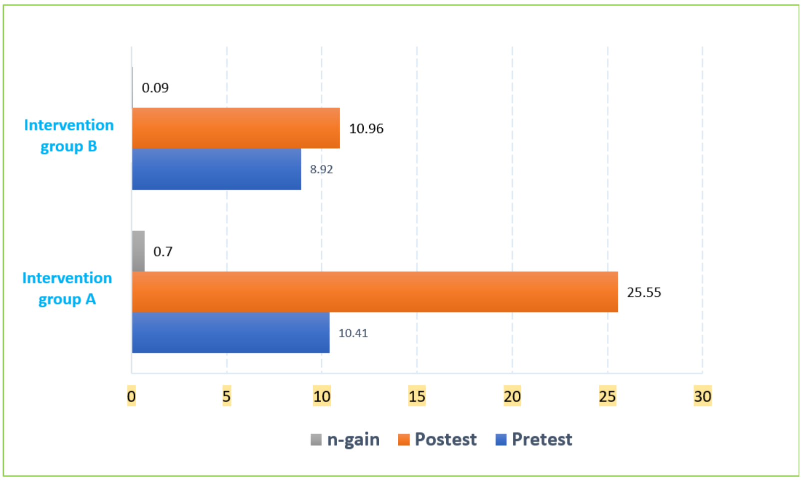

Figure 2. Results of the CTs measurement of the two groups

Next, a statistical analysis of differences in CT skills for each group was carried out. This was preceded by a normality test for each group (see Table 6). The results of the normality test showed that both test groups were normally distributed, meaning that a different test could be used (parametric assumptions were met). The results of the paired *t* test are presented in Table 7.

Table 6. Results of the normality test ($p > .05$)

Group		n	Mean	SD	Sig.	Normality
Intervention group A	Pretest	29	10.413	1.991	.200	Normal distribution
	Posttest	29	25.551			
Intervention group B	Pretest	26	8.923	1.768	.200	Normal distribution
	Posttest	26	10.961			

Table 7. Paired *t* test results ($p < .05$)

Group		n	Mean	SD	df	t	Sig.
Intervention group A	Pretest	29	10.413	2.009	28	-33.741	.000
	Posttest	29	25.551	1.638			
Intervention group B	Pretest	26	8.923	1.958	25	-5.706	.000
	Posttest	26	10.961	1.280			

The results of the paired *t* test in Table 7 showed that there were differences in the two sample groups' CT skills between the pretest and posttest, with a significance value of $p < .05$. The effect of intervention differences between groups on the improvement of CT skills (n-gain parameters) was analyzed using an independent sample *t* test. The results are shown in Table 8.

Table 8. Independent sample *t* test results of the two sample groups ($p < .05$)

Measurement		t	df	Sig. (2-tailed)	Std. err. diff.	95% Conf. int. diff.	
						Lower	Upper
n-gain of CT skill	Equal variances assumed	30.526	53	.000	2.014	57.462	65.545
	Equal variances not assumed	30.707	52.999	.000	2.003	57.486	65.521

Table 8 confirms that there was a significant difference in CT skills results between the two intervention groups (A and B), with a significance value of $p < .05$.

4. Discussion

In-depth knowledge in the fields of science must be supported by the CT skills of science students. In this study, the initial assessment (pretest) based on the results in Table 4 (the CTi parameter) indicated that both intervention groups in the pretest were at the less critical level. Our analysis showed that PSTs are not trained in their learning experience to think critically. As the results of Fitriani et al. (2019) showed, the teaching routines at universities are not aimed at fostering CT skills, with students' analytical abilities and CT skills being underdeveloped. Similar results were found for mechanical engineering students at a university in Taiwan who wanted a change in perspective and reform of education towards fostering CT (Hsu, 2021). A CT skills pre-assessment showed poor performance in CT and was far from what the university expected.

In the current study, the opportunity to develop CT skills in PSTs was widely broadened by implementing inquiry learning, which is recognized as a pedagogy used in training CT skills. In this study, intervention group A (inquiry-creative learning integrated with ethnoscience) acquired a CTi score at the critical level, outperforming intervention group B (traditional teaching), who were at the less critical level. Visualization of the CTi results (see Figure 1) convincingly showed that intervention group A achieved a much superior CTi score than intervention group B. For group B, there was almost no increase in CTi (n-gain was very small – 0.09). Intervention group A achieved the most significant increase in CTi, as shown by the analysis indicators, with high n-gain criteria, and other indicators, with moderate criteria. This is clearly due to scientific-creativity interventions that have been able to improve CT skills. This finding is in line with that of previous studies, reporting that better analytical skills are found in prospective teachers when scientific creativity is integrated into inquiry teaching (Wahyudi et al., 2019). When compared to traditional teaching, inquiry learning is better. This is in line with Furtak et al.'s (2012) findings that inquiry learning is better for improving students' skills and learning outcomes when compared to traditional teaching.

The CTs performance of participants on the pretest for both intervention groups was at a less critical level, while the posttest showed various increases in CTs skills. In the posttest, the CTs performance of intervention group A was found to be superior, at the critical level, and the CTs performance of group B was found to be the lowest, at a less critical level (there was no change in CTs level between the pretest and posttest in this group). The highest increase in CTs scores (n-gain) was found for intervention group A. Statistically, the CTs scores at pretest-posttest differed between the two groups (see paired *t* test results in Table 7). Our assumption specifically for traditional teaching is that CTs scores increased (although the increase looks small) as a result of material conduction in this group. When compared with traditional teaching, it is clear that inquiry-creative learning integrated with ethnoscience is better. Even when compared to another cooperative teaching method such as student teams-achievement divisions (STAD), the inquiry model is better at training CT skills (Pahrudin et al., 2021). Nonetheless, we emphasize again that inquiry-creative learning integrated with ethnoscience is much better in improving the CT skills of PSTs. The significant difference in CT skills scores between the two intervention groups (A and B) is confirmed by the results in Table 8.

Inquiry-creative learning integrated with ethnoscience has the advantage over traditional teaching for various reasons, as will be explained next. The differences between traditional teaching and inquiry-creative learning integrated with ethnoscience in the context of the current study are presented in Figure 3. In our study, traditional teaching is identified with expository teaching (Suweta, 2020), while inquiry-creative learning is based on the results of the development in a recent study by Wahyudi et al. (2018, 2019), which is then integrated with ethnoscience.

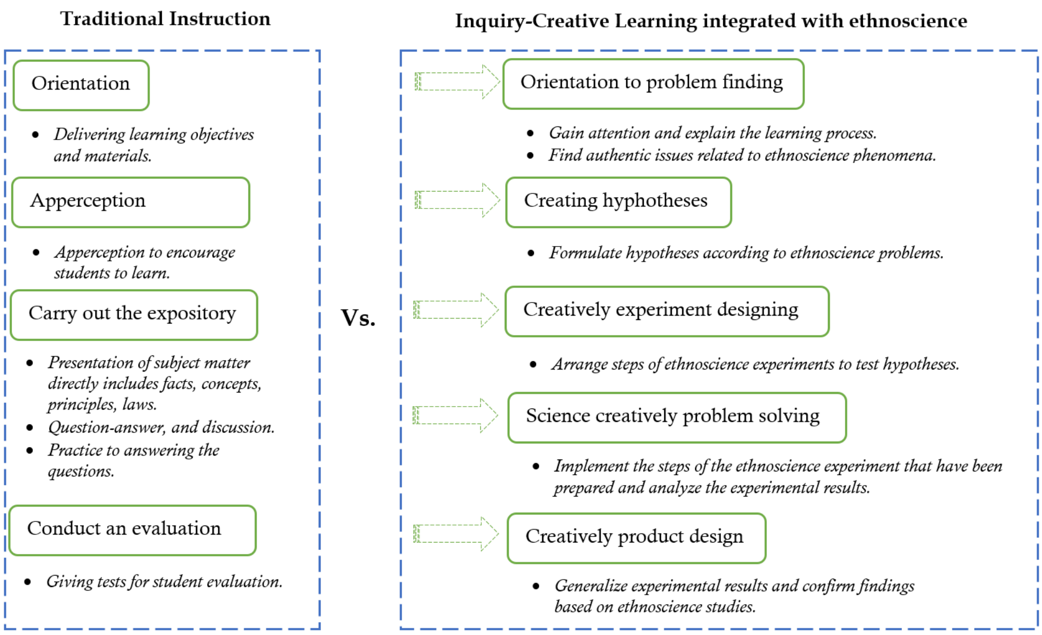

Figure 3. Difference between traditional teaching and inquiry-creative learning integrated with ethnoscience

Inquiry-creative learning integrated with ethnoscience can be superior in training the CT skills of PSTs when compared to traditional teaching for various important reasons (Figure 3). First, the orientation phase is focused on problem finding, where PSTs are asked to find as many authentic issues and discrepant events about ethnoscience as possible. This kind of encouragement can broaden the spectrum of PST thinking by exploring not only one focus of the problem but as many as possible. Their creative ideas will emerge when they receive such encouragement. Dimensionally, critical and creative thinking are different, but the intervention of scientific creativity in finding problems has a positive impact on students' CT skills (Birgili, 2015). An important instrument that can serve as navigation to build students' thinking skills in inquiry is to find problems and solve them creatively (Doss, 2018). Therefore, inquiry should not be taught in ordinary ways but should begin by encouraging students to find problems creatively and solve them (Jia et al., 2017). Second, the encouragement to creatively hypothesize and design creative experiments about ethnoscience becomes a stimulus in PSTs' creative thinking, which results in building deeper knowledge by experimenting with creativity. Creative ideas in experimenting strengthen students' scientific knowledge and science process skills (Verawati et al., 2022; Zainuddin et al., 2020), and this has an impact on their CT skills (Wahyudi et al., 2019). Third, the value of encouraging critical thinking through the process of evaluating creative experimental procedures about ethnoscience has been confirmed by the findings of this study. Experimental creativity requires high imaginative capability and creative thinking skills of students (Haryani et al., 2021), and when there is an urge to evaluate the creative experimental procedures compiled, it can improve their CT skills. Creative ways of experimenting are needed for PSTs. This can have a more advanced impact on their CT skills (Chen & Chen, 2021). Fourth, presenting scientific-creativity products about ethnoscience is the main outcome of the CT skills of PSTs. It is considered a product of CT as long as the products are experimented with creatively. Finally, all intervention forms of inquiry-creative learning integrated with ethnoscience have a better impact on supporting the CT skills of PSTs compared to traditional teaching.

We want to emphasize that the inquiry instruction popularized by Arends (2012) is different from the inquiry-creative learning integrated with ethnoscience used in this study. Arends' (2012) inquiry instruction is focused on one problem or discrepant event. Focusing on one problem is not necessarily appealing to different PSTs, because of the different learning experiences, and this has an impact on the process of manipulating the ideas of inquiry. This factor is also a finding in previous studies, showing that students are not so good at manipulating their ideas in inquiry (Rahmawan et al., 2020). This also has an impact on students' dependence on teacher instructions in inquiry learning. Although teacher instruction is considered effective for mastering the content domain in inquiry (van der Graaf et al., 2019), it is also considered a factor that causes students' initiative and CT skills to be less developed (Mutmainah et al., 2019). This weakness is addressed in inquiry-creative learning integrated with ethnoscience. In this approach, various issues are verified and then solved creatively, where each PST freely manipulates their creative ideas. Finally, without neglecting inquiry learning, this study provides a reference point that in training the CT skills of PSTs, learning processes should be oriented to apply inquiry-creative learning integrated with ethnoscience.

5. Conclusion, Implication, and Limitations

This study implemented inquiry-creative learning integrated with ethnoscience in an experimental study framework. The performance assessment of the CT skills of PSTs in the two intervention groups, inquiry-creative learning integrated with ethnoscience, and traditional teaching, showed different results. For the parameters of CTi and CTs, inquiry-creative learning integrated with ethnoscience has a better impact on training the CT skills of PSTs compared to traditional teaching. The statistical analysis results showed a significant difference in the CT performance of participants between the two groups. The results of this study emphasize that in relation to improving CT performance, teaching practice with inquiry-creative learning integrated with ethnoscience is the most effective method in improving the CT skills of PSTs.

The implication of the findings of this study is the feasibility of applying inquiry-creative learning integrated with ethnoscience broadly and extensively in science education to train the CT skills of PSTs. Although the study proved successful, it was not without limitations. First, participating PSTs' responses to each learning intervention were not assessed, reducing information about their interest in each learning intervention. Second, this study did not measure the dispositional aspect of CT, where the dispositional aspect complements the acquisition of CT skills in learning. Third, the learning program was carried out on one subject only and was of relatively short duration. Future research thus needs to conduct similar learning interventions with a variety of different materials in longer learning activities.

6. Acknowledgement

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