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Influence of Challenge-Based Learning (CBL) Incorporating Pulo Gold-craft Ethnoscience to Improve Science Students' Creative Thinking Skills

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Abstract: The Challenge-Based Learning (CBL) model synthesises problem-based, project-based, and contextual learning approaches into an integrative pedagogical framework. Ethnoscience connects indigenous knowledge systems with scientific inquiry and provides cultural relevance to science education. This study focuses on the gold and silver craftsmanship of Pulo Village in Tempeh Subdistrict—a generational practice rooted in local ethnoscientific traditions, where artisans employ empirically derived metallurgical techniques. By embedding these indigenous practices into CBL, the research investigates how ethnoscience-informed pedagogy enhances junior high school students' creative thinking skills in understanding temperature, heat, and thermal expansion. Quasi-experimental research followed a posttest-only control group design and was conducted using a purposive sampling technique in the 7th grade at SMPN 7 Tempeh, Lumajang, Indonesia. Primary data was a creative thinking skills posttest, while secondary data was interviews and documentation. Sample data were analysed using homogeneity and normality tests using Kolmogorov-Smirnov. The data proved normal, so the hypothesis test used the Independent Sample T-test. The results obtained showed that there was an effect of creative thinking on students with a two-sample t-test value of significance (2-tailed) ($0.003 \leq 0.05$) and the right-tailed t-test, which obtained the value of tcount> ttable (3.097> 2.005). It was concluded that this study, with the application of the ethnoscience-based Challenge-Based Learning (CBL) approach, will influence the improvement of the creative thinking of junior high school students. In the CBL, the learners would collaboratively compose their ideas to solve problems and adjust some results to strengthen creative thinking skills aligned with culturally relevant real-world challenges.

Keywords: challenge-based learning, ethnoscience, creative thinking skills.

▪ INTRODUCTION

Natural Science (IPA) studies natural phenomena, rooted in human curiosity and systematic discovery (Sari et al., 2024). As a discipline, it fosters logical, critical, and creative thinking, as well as collaborative abilities essential for 21st-century education (Ayuni et al., 2024). Modern pedagogical frameworks emphasise the 4Cs: collaboration, communication, critical thinking, and creativity (Handini & Mustofa, 2020). Among these, creative thinking is particularly vital, enabling learners to generate innovative ideas and adapt to global challenges (Qulsum & Hermanto, 2022; Zein et al., 2022). Another creative process result is an imaginative, flexible, sequential, and discontinuous product, which is essential for solving complex problems (Septimawati, 2022). Therefore, educational systems must produce graduate competencies by fostering higher-order thinking skills in science students (Sumarni & Kadarwati, 2020).

Creative thinking arises from habitual practice, involving intuition, imagination, and the exploration of novel perspectives (Fairazatunnisa et al., 2021; Yildiz, 2021). Its core indicators, fluency, flexibility, originality, and elaboration (Hasanah et al., 2023; Dila et al., 2024) must be cultivated early to prepare students for future demands.

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However, creative thinking skills in Indonesia remain underdeveloped due to teacher-centred, conventional methods (Fairazatunnisa et al., 2021). This is reflected in Indonesia's 85th-place ranking out of 129 countries in the Global Creativity Index (Hasanah et al., 2023). Empirical studies further highlight this issue. Harefa et al. (2024) found that Class IX students at SMP Negeri 3 Lotu exhibited low creative thinking, with short, underdeveloped essay responses and an average score of 40 (categorised as "less creative"). Ayuni et al. (2024) observed similar trends at SMPN 1 Jombang, where creative thinking indicators averaged 2.9%–31.93%. Alamanda et al. (2024) attributed this deficit to insufficient optimised learning strategies in Surakarta State Junior High School.

The dependence on lecture-based methods limits opportunities for creative engagement (Harefa et al., 2024). To address this, developed models like Challenge-Based Learning (CBL), which integrates problem-based, project-based, and contextual learning, are needed (Naim et al., 2020). The CBL is collaborative and hands-on, encouraging students to learn with classmates, teachers, and experts in their societies and around their surroundings to ask excellent questions, improve more profound subject knowledge, accept and tackle challenges, and undertake and share their experiences. CBL's three-phase syntax (Engage, Investigate, Act) strengthens students to solve real-world problems, boosting their creativity (Fairazatunnisa et al., 2021; Nichols et al., 2016). Creative thinking skills are important for generating new ideas and gauging the effectiveness of existing solutions in solving complex problems (Sumarni& Kadarwati, 2020).

Ethnoscience bridges indigenous knowledge and scientific inquiry, cultivating learning with cultural relevance (Wanggi et al., 2023; Fahrozy et al., 2022). The science learning based on the local wisdom provides a more contextual and meaningful knowledge discourse, so that it can foster creativity to solve students' real-world problems. For instance, Pulo Village's gold and silver craftsmanship is a generational livelihood that provides a tangible context for teaching temperature, heat, and expansion topics often perceived as challenging (Supriyadi et al., 2021). By embedding such local wisdom into CBL, students can delve into scientific concepts while preserving cultural heritage (Wanggi et al., 2023). Furthermore, typical knowledge of society, such as Pulo gold-craft ethnoscience, is also important for developing the learners' character.

The Challenge-Based Learning (CBL) approach has widely cultivated problem-solving and collaborative skills in science learning (Nichols et al., 2016; Gallagher & Savage, 2020). However, its integration with ethnoscience, especially local wisdom such as Pulo gold-craft, remains unexplored. Most existing CBL research predominantly emphasises generic STEM challenges or Western-centric contexts, overlooking culturally rooted frameworks that could enhance relevance and engagement for diverse learners. Meanwhile, typical knowledge of local society is also vital in developing the students' character (Sudarmin et al., 2019; Sumarni & Kadarwati, 2020). Thus, this study addresses the gap by embedding Pulo gold-craft ethnoscience into CBL, investigating how localized knowledge uniquely improves creative thinking skills in science students.

Filling this research void, incorporating local culture aspects into a structured pedagogical approach like CBL demonstrates significant potential for advancing creative competencies. Focusing on junior high school students at SMPN 2 Tempeh, this research investigates the impact of Pulo gold-craft-integrated CBL on improving creative thinking

skills. The results aim to provide actionable insights for educators, bridging the difference between abstract scientific concepts and culturally relevant real-world implementation. This work seeks to reinforce the quality of science education at the middle school level by positioning ethnoscience as a transformative method for preserving Indigenous heritage in innovative education.

▪ METHOD

Participant

This teaching activity was conducted two weeks in November 2024 (odd semester, 2024/2025 academic year) at SMPN 2 Tempeh, involving seventh-grade students as the target population (N=196 students across seven classes). Purposive sampling ensured the selection of experimental and control groups with comparable characteristics and confirmed homogeneity, allowing results to generalise to the population. The two classes selected have homogeneous attributes and have been previously tested by the Levene test to ensure their homogeneity.

Research Design

The quasi-experimental posttest-only control group design evaluated the effect of Challenge-Based Learning (CBL) grounded in Pulo Gold-craft Ethnoscience on students' creative thinking skills. Following the framework proposed by Istighfarini et al. (2024), participants were divided into two groups: the experimental group engaged in ethnoscience-integrated CBL activities, while the control group received conventional instruction. Both groups completed identical posttests to measure creative thinking outcomes, with no pretest administered. This design enabled direct comparison of post-intervention performance, minimising confounding variables and isolating the pedagogical effects of the CBL approach.

SMPN 2 Tempeh implemented the Merdeka curriculum in designing learning outcomes (CP), learning objective sequences (ATP), and teaching materials, covering topics such as temperature, heat, and expansion (Lulita et al., 2024). The study consisted of six sessions per class, including the experimental and control groups. The experimental class followed CBL's three-phase framework: engage, investigate, and act. The engage phase introduced core concepts through real-world challenges, while the investigate phase involved guided questions and resources to analyse apparent problems. Finally, the act phase culminated in presenting a creative solution. After the intervention, a posttest was administered, including four essay questions assessing the four indicators in creative thinking (Nichols et al., 2016).

Data Analysis

Data collection included creative thinking posttest scores, supplementary interviews, and documentation. We analysed the data using descriptive statistics (minimum, maximum, and mean values) and conducted hypothesis testing to assess significant differences. Furthermore, Statistical investigations were performed using SPSS 26, including a Homogeneity test, Kolmogorov-Smirnov tests for normality assessment, and independent samples t-tests for hypothesis testing (right-tailed).

The criteria for assessment of students' creativity were determined using a predefined scoring interval system. Learners' performance was classified into five categories based on their percentage scores: Very Good (81.26–100%), Good (62.51–

81.25%), Simply (43.76–62.50%), Less (25.00–43.75%), and Very Less (0–24.9%). This classification provides a systematic method for illustrating the extent to which students demonstrated creative thinking capacities, allowing for clear differentiation between high, moderate, and low proficiency levels.

▪ RESULT AND DISSCUSSION

This study investigated the influence of an ethnoscience-based Challenge-Based Learning (CBL) model on enhancing creative thinking in seventh grade at SMPN 2 Tempeh. A homogeneity test was conducted as a preliminary step to assess population variance using SPSS 26, including information on the sampling strategy. The Levene results indicated homogeneity with the statistical test of 1.950 and a significance value of 0.075 (> 0.05). The sample was selected using the purposive sampling area method for both the experimental and control classes. These classes were determined based on the two closest average scores from previous daily tests on the aforementioned topic. The mean scores of class VII-A (90.00) and class VII-C (89.63) differed by only 0.37, making them suitable for comparison. Consequently, class VII-A (29 students) was assigned as the experimental group, receiving the ethnoscience-based Challenge-Based Learning (CBL) model. In comparison, class VII-C (27 students) served as the control group, taught using the conventional Cooperative Learning model implemented by teachers.

Creative thinking skills are essential for addressing complex global challenges (Aulia, 2023), making their development a critical educational objective. The research was conducted at SMPN 2 Tempeh, selected based on several criteria: (1) its proximity to Pulo village, a local gold and silver craft center, providing relevant ethnoscience context; (2) the absence of prior studies using ethnoscience-based CBL models at this school; and (3) the novelty of the research topic within this setting. Using purposive sampling, two classes were selected: VII-A (intervention class, n = 29) and VII-C (conventional class, n = 27).

The posttest administered outside regular learning sessions measured students' creative thinking skills in Temperature, Heat, and Expansion topics. The descriptive outputs were summarised in Table 1. The experimental class achieved a higher average posttest score (72.93) than the control class (57.04). The lowest score in the treatment group was 25, while the control group had a minimum score of 30. Conversely, the highest score in the experimental class (95) exceeded that of the control class (85).

Table 1. Recapitulation of creative thinking skills posttest grades

Component	Experimental Class Posttest	Posttest Kelas Control
Lowest score	25	30
Highest score	95	85
Mean	72.93	57.04

To evaluate the research objective, assessing the effect of ethnoscience-based CBL on enhancing creative thinking, the posttest scores of both classes were analysed. Before conducting an independent samples t-test, normality checks were conducted to ensure the validity of the statistical comparisons. A normality test, planned to assess posttest scores of students' creative thinking in the innovation cohort, presented a significance rate of

0.054 (> 0.05). In contrast, the control group posttest yielded a significance value of 0.095 (> 0.05). Since both values exceed the 0.05 threshold, the data can be considered normally distributed, justifying parametric tests, specifically the Student's t-test for independent samples. Two group t-tests were employed to determine whether a significant statistical difference was observed between the experimental and control classes. The t-test results are summarised in Table 2.

Table 2. Independent sample t-test results

	t	df	Sig. (2-tailed)	t_{table}
Equal variances assumed	3.097	54	0.003	2.005

Statistical analysis validated these findings because an Independent samples t-test had a p-value of 0.003 ($p < 0.05$), rejecting the null hypothesis. The right-tailed test, where tcount was 3.097, was greater than the ttable at 2.005, further validating the better performance of the experimental group. This demonstrates a statistically significant difference in the creative thinking results between using CBL in Pulo Gold-craft etnoscience and conventional teaching methods. These findings validate existing research on CBL's efficacy, particularly Damayanti et al.'s (2017) demonstration of how ethnoscience-integrated approaches develop learning outcomes and creative thinking skills. The wax melting experiment illustrates this pedagogical effectiveness, serving as more than just abilities training in assessment and observation. The activity cultivated deeper conceptual understanding by contextualizing phase changes and heat transfer within authentic cultural routines while manifesting applied applications of scientific rules.

Table 3. Table of percentage criteria for creative thinking scores

Indicators of Creative Thinking Skills	Experiment Class		Control Class	
	Posttest	Category	Posttest	Category
Fluency	81.4%	Very good	73.3%	Good
Flexibility	67.6%	Good	50.4%	Simply
Originality	74.5%	Good	57.0%	Simply
Elaboration	68.3%	Good	47.4%	Simply

Table 3 shows a significant difference in the percentage distribution of creative thinking skill criteria between the experimental and control classes. Overall, the intervention class achieved higher percentages than the baseline class. Specifically, the treatment class attained its highest percentage (81.4%) in the fluency indicator, falling under the excellent category, while the lowest percentage (67.6%) was observed in the flexibility indicator, classified as good. In contrast, the control class scored a maximum of 73.3% (good category) in fluency and a minimum of 47.4% (sufficient category) in elaboration. A comparative visualisation of these results for each creative thinking indicator in both classes is provided in Figure 1.

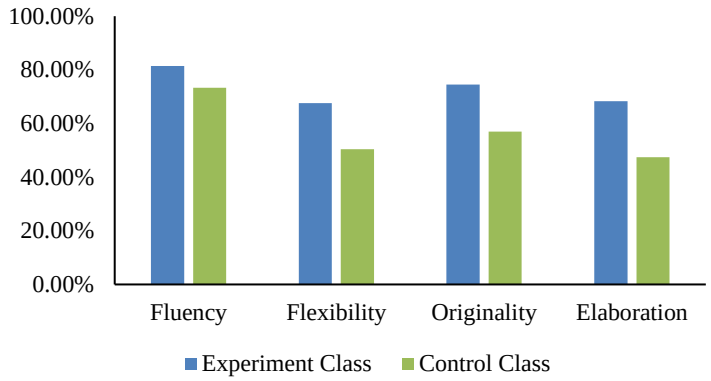

Figure 1. Chart of percentage criteria for creative thinking skills scores

An essential activity in the engagement phase was the "Gold Smelting Simulation," where student groups simulated gold melting with basic materials like candle wax. This hands-on activity immediately captured students' curiosity about improving essential questions in the topic. Students investigated the causes of wax melting and determined its melting point through guided inquiry. This experiment enabled them to observe temperature changes and physical transformations, reinforcing heat transfer concepts while fostering their flexibility skills. Fairazatunnisa et al. (2021) also pointed out that flexibility enables learners to create diverse arguments and solutions from various stances (investigate phase). Students demonstrated interdisciplinary understanding by analysing heating patterns (e.g., temperature vs. time graphs) and connecting wax melting to gold-smithing processes (act phase). Figure 2 displays students experimenting.

Figure 2. Students do the Gold Smelting Simulation using a burning candle

The results indicate that the ethnoscience-based CBL model significantly enhances students' creative thinking skills. The experimental group recorded a higher mean score (72.9%) compared to the control group (57.0%), and their creative thinking indicators were rated "good" compared to the control group's "sufficient" rating. The findings confirm Mustofa et al.'s (2021) argument that the effectiveness of treatment can be determined by comparative group analysis. The latest experiment class, trained by the ethnoscience learning, has improved their knowledge and understanding to address specific issues from their cultural perspectives. Challenges assisted the students' creative thinking in tackling the issues through project duties. In the CBL, the learners would

collaboratively try to compose their ideas to solve problems and adjust some results to strengthen creative thinking skills (Darling-Hammond et al., 2019).

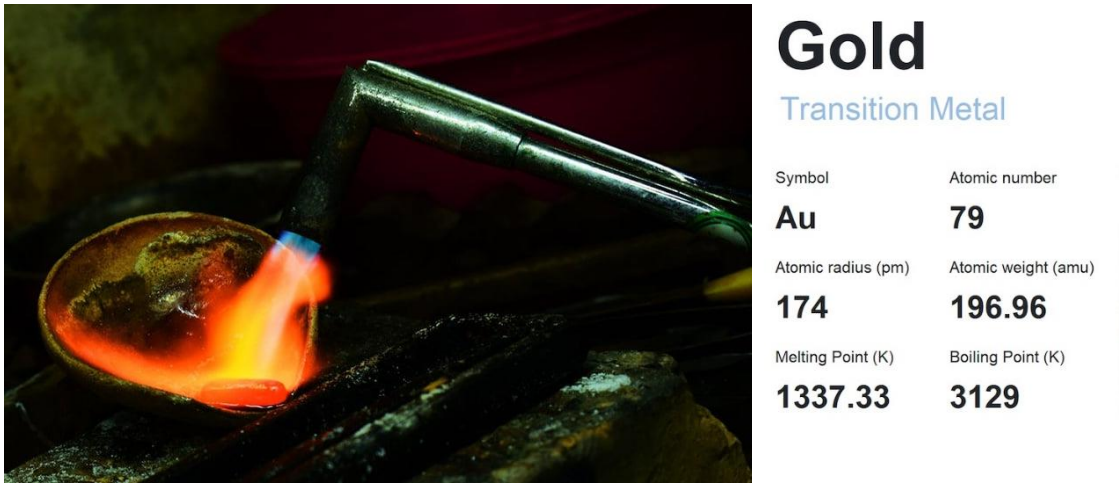

Figure 3. Gold smelting in pulo goldcraft and the melting point

The Pulo Gold-craft Ethnoscience Learning permitted students to describe substantial analogies between wax melting and goldsmithing metallurgical processes. Through the comparative method, students recognised identical aspect transition principles. Both materials transform from solid to liquid state and shift upon reaching their characteristic melting points (wax at 38°C versus gold at 1064°C, with gold's boiling point at 2856°C). The CBL approach successfully addressed the empirical challenge of measuring wax's specific melting forms while clarifying these properties with gold's established thermal variables from a literature survey.

▪ CONCLUSION

This study concludes that the ethnoscience-based Challenge-Based Learning (CBL) in *Pulo* Gold-craft improves junior high school students' creative thinking. The evidence was given by the higher average score of the intervention class (72.9%) compared to the traditional cohort (57.0%) in the assessment of creativity criteria. Furthermore, the empirical class demonstrated "good" performance in creative thinking indicators, whereas the control remained in the "sufficient" category. The statistical analysis further supports this finding. A two-sample *t*-test revealed a significant contrast between both groups ($p = 0.003 < 0.05$). Additionally, a right-tailed *t*-test confirmed that the experimental class outperformed the baseline, with the calculated *t*-value exceeding the critical *t*-value ($t_{count} = 3.097 > t_{table} = 2.005$), indicating that the ethnoscience-based CBL model effectively develops students' creative thinking compared to conventional methods. In the CBL, the learners would collaboratively compose their ideas to solve problems and adjust some results to strengthen creative thinking skills aligned with culturally relevant real-world challenges.

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