Available online at: https://journal.upgripnk.ac.id/index.php/saintek
Jurnal Pendidikan Informatika dan Sains
13(2), 2024, 271-278
E-ISSN: 2407-1536
P-ISSN: 2089-2802

THE EFFECT OF ETHNOSCIENCE-BASED PHYSICS LEARNING ON STUDENTS' ANALYTICAL SKILLS IN CULTURAL CONTEXTS

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Received: 2024-06-5 Accepted: 2024-11-3 Published: 2024-12-28

Abstract
Ethnoscience-based learning integrates local cultural knowledge into science education, providing students with contextually meaningful learning experiences. This study investigates the effect of ethnoscience-based physics learning on students' analytical skills in cultural contexts. A quasi-experimental design with a non-equivalent control group was employed, involving 72 high school students in West Kalimantan, Indonesia. The experimental group received ethnoscience-based physics instruction incorporating Malay cultural practices and traditional knowledge systems, while the control group received conventional physics instruction. Analytical skills were measured using a validated instrument comprising 25 items aligned with Bloom's taxonomy (analysis level). Results revealed that students in the experimental group demonstrated significantly higher analytical skills compared to the control group ($t = 4.87$, $p < 0.001$, $d = 1.12$). Qualitative analysis of student reflections indicated that cultural contexts enhanced students' motivation to analyze physical phenomena. These findings suggest that ethnoscience-based physics learning is a promising pedagogical approach for developing analytical skills while preserving cultural heritage. Implications for curriculum development and teacher training are discussed.
Keywords: *ethnoscience, physics education, analytical skills, cultural context, Malay culture, inquiry-based learning*

How to cite (in APA style): Nurussaniah, N., & Sulistiawan, H. (2024). The effect of ethnoscience-based physics learning on students' analytical skills in cultural contexts. *Jurnal Pendidikan Informatika Dan Sains, 13*(2), 271–278. https://doi.org/10.31571/saintek.v13i2.10910.

DOI: 10.31571/saintek.v13i2.10910

INTRODUCTION

Science education in the twenty-first century faces a fundamental challenge: bridging the gap between universal scientific principles and the culturally embedded ways in which learners experience and understand the world. Physics, as one of the foundational sciences, is often perceived by students as abstract, decontextualized, and disconnected from their daily lives (Aikenhead & Jegede, 1999). This perception is particularly pronounced among students from non-Western cultural backgrounds, where local knowledge systems and scientific canon rarely intersect in formal educational settings. Ethnoscience-based learning has emerged as a promising pedagogical response to this challenge, proposing that indigenous and local cultural knowledge can serve as a meaningful scaffold for building scientific understanding (Cobern & Loving, 2001).

The concept of ethnoscience refers to the systematic study of how people from a particular culture perceive and categorize natural phenomena (Snively & Corsiglia, 2001). Within the field of education, ethnoscience-based learning leverages these cultural systems of knowledge to create instructional environments that are both scientifically rigorous and culturally responsive. Numerous studies have demonstrated its positive effects on students' engagement, motivation, and conceptual understanding in science (Bang & Medin, 2010; Metz, 2011). However, comparatively fewer studies have explored its specific influence on higher-order cognitive skills such as analytical thinking, particularly within the physics domain.

Analytical skills are among the most valued outcomes of science education, representing students' capacity to decompose complex information, identify relationships between components, and evaluate evidence-based arguments (Bloom et al., 1956; Anderson & Krathwohl, 2001). In physics, analytical skills are particularly critical, as they underpin the ability to interpret experimental data, construct explanatory models, and solve multi-step problems (Docktor & Mestre, 2014). Despite their centrality, many students especially those in culturally diverse contexts struggle to develop robust analytical skills in conventional physics classrooms that privilege Western scientific epistemology (Harding, 1998).

West Kalimantan, Indonesia, offers a particularly rich setting for examining the intersections of culture and physics education. The Malay cultural tradition of the region encompasses a wealth of traditional practices, craftsmanship, and knowledge systems that embody sophisticated physical principles from the hydrodynamics underlying traditional river-based transportation to the structural mechanics implicit in the construction of stilt houses and ceremonial boats (Wahab et al., 2019). These cultural artifacts provide tangible, locally meaningful contexts through which abstract physics concepts can be explored and analyzed.

Research in culturally responsive science pedagogy has established that students who encounter scientific concepts through familiar cultural lenses are more likely to engage in deep cognitive processing and critical analysis (Gay, 2000; Ladson-Billings, 1995). Specifically, ethnoscience-based instruction has been associated with improved science achievement among indigenous and minority students (Kimmerer, 2013; McKinley & Stewart, 2012). However, the mechanism through which cultural contextualization enhances analytical skills rather than mere factual recall remains underexplored in the literature. A deeper understanding of this mechanism is essential for designing effective physics curricula in culturally diverse educational contexts.

The present study addresses this gap by investigating whether ethnoscience-based physics learning, specifically informed by West Kalimantan Malay cultural practices, produces measurable gains in students' analytical skills compared to conventional instruction. Three research questions guide the inquiry:

(1) Is there a significant difference in analytical skill scores between students receiving ethnoscience-based and conventional physics instruction?
(2) What aspects of ethnoscience-based learning most strongly predict analytical skill development?
(3) How do students describe the role of cultural context in their physics reasoning processes?

By answering these questions, this study aims to contribute both to the theoretical understanding of culturally responsive science pedagogy and to the practical development of evidence-based physics curricula in Indonesia and similar cultural contexts worldwide.

LITERATURE REVIEW

Ethnoscience and Science Education

Ethnoscience, as a field of inquiry, has its roots in anthropological studies of how different cultures classify and understand the natural world (Atran, 1990). In education, the concept was operationalized by Snively and Corsiglia (2001), who argued that indigenous science knowledge represents a legitimate and internally consistent body of knowledge that should be recognized alongside Western modern science. This perspective challenges the historically dominant assumption that science is a culturally neutral enterprise and calls for more pluralistic epistemological frameworks in science education.

Aikenhead and Jegede (1999) developed the concept of 'border crossing' to describe the cognitive and cultural transitions students must navigate when moving between their indigenous knowledge world and the world of Western science in school. Students who lack support for this transition often experience cognitive conflict and disengagement. Ethnoscience-based instruction is designed to reduce the friction of this border crossing by creating curricular bridges between students' cultural knowledge and canonical science content (Cobern & Loving, 2001).

Analytical Skills in Physics Education

Analytical skills, as defined within the revised Bloom's taxonomy (Anderson & Krathwohl, 2001), encompass the cognitive processes of differentiating, organizing, and attributing that is, distinguishing relevant from irrelevant information, determining how elements relate within a larger structure, and identifying the perspective or bias underlying a communication. In physics, these processes manifest in tasks such as analyzing force diagrams, decomposing motion into vector components, evaluating experimental designs, and critiquing theoretical models (Docktor & Mestre, 2014).

Studies consistently show that conventional physics instruction, which emphasizes procedural problem-solving and formula application, produces limited development of analytical skills (Hestenes et al., 1992). Inquiry-based and problem-based learning approaches have shown greater promise for cultivating analytical thinking, as they require students to engage actively with evidence and construct their own explanations (Hmelo-Silver et al., 2007). Ethnoscience-based learning can be understood as a particular variant of contextualized inquiry, in which the problem context is drawn from students' own cultural heritage.

Cultural Contexts and Cognitive Development

Vygotsky's (1978) sociocultural theory provides a foundational framework for understanding how cultural tools and practices mediate cognitive development. From this perspective, the cultural contexts in which students encounter scientific phenomena are not merely motivational scaffolds but constitute the very cognitive tools through which analytical thinking is structured and expressed. Bang and Medin (2010) extended this argument by demonstrating that indigenous students who engaged in science activities organized around culturally familiar ecological knowledge showed qualitatively different and more sophisticated patterns of causal reasoning than those in decontextualized science instruction.

In the Indonesian context, several studies have documented the educational potential of local cultural knowledge for science learning. Sudarmin et al. (2019) found that ethnoscience-based chemistry instruction improved high school students' critical thinking skills in Central Java. Wahab et al. (2019) demonstrated that incorporating Malay traditional boat-building knowledge into a physics curriculum enhanced students' understanding of buoyancy and fluid mechanics. These findings support the hypothesis that culturally grounded instruction can promote not only conceptual understanding but also higher-order analytical reasoning.

METODE

Research Design

This study employed a quasi-experimental design with a non-equivalent control group pretest-posttest structure (Creswell, 2014). This design was selected because random assignment of students to experimental conditions was not feasible within the intact classroom structure of the participating school. The experimental group received ethnoscience-based physics instruction, while the control group received conventional physics instruction over a six-week period.

Participants

Participants were 72 tenth-grade high school students (36 male, 36 female; mean age = 15.8 years, SD = 0.6) from two intact classes at a public senior secondary school in Pontianak, West Kalimantan, Indonesia. Class assignment to experimental or control conditions was determined by the school schedule. Both classes were taught by the same physics teacher to control for teacher effects. All participants self-identified as members of the local Malay cultural community and reported familiarity with the traditional practices used as instructional contexts.

Instructional Treatment

The ethnoscience-based physics curriculum was developed by the research team in collaboration with local cultural experts and the participating teacher. The curriculum addressed five physics topics aligned with the national curriculum: Newton's laws of motion, work and energy, fluid statics, heat transfer, and wave mechanics. For each topic, instructional contexts were drawn from Malay cultural practices: traditional boat racing (motion and forces), rice-pounding ceremonies (work and energy), traditional stilt house construction (fluid statics), traditional batik dyeing (heat transfer), and traditional percussion instruments (wave mechanics). Lessons followed a five-phase inquiry cycle: cultural exploration, phenomenon observation, concept development, application, and reflection (Sudarmin et al., 2019).

Instrument

Analytical skills were assessed using a 25-item instrument developed by the research team based on Bloom's revised taxonomy (Anderson & Krathwohl, 2001) and the Physics Analytical Reasoning Scale adapted from Docktor and Mestre (2014). Items required students to decompose physics problems embedded in cultural scenarios, identify relationships among physical variables, and evaluate the adequacy of competing explanations. The instrument was validated through expert review (content validity ratio = 0.87) and a pilot study (Cronbach's alpha = 0.82, n = 30). Each item was scored on a four-point rubric, yielding a maximum total score of 100.

Data Analysis

Pretest-posttest scores were compared using analysis of covariance (ANCOVA), with pretest scores as the covariate, to control for initial group differences. Cohen's d was computed to estimate the practical significance of the treatment effect. Qualitative data from student reflective journals were analyzed using thematic analysis (Braun & Clarke, 2006), following an inductive coding procedure. Trustworthiness was established through member checking and inter-rater reliability (Cohen's kappa = 0.79) on a 20% subsample of journal entries.

RESULTS AND DISCUSSION

Descriptive Statistics

Table 1 presents the pretest and posttest descriptive statistics for both groups. The experimental group showed a mean gain of 24.3 points (SD = 8.7), compared to a mean gain of 11.6 points (SD = 9.2) in the control group, indicating that the ethnoscience-based instruction produced substantially greater improvements in analytical skills.

Table 1. Descriptive Statistics for Analytical Skill Scores

Group	Pre-M (SD)	Post-M (SD)	Gain	Min	Max
Experimental (n=36)	48.2 (9.4)	72.5 (8.1)	24.3 (8.7)	54	92

Group	Pre-M (SD)	Post-M (SD)	Gain	Min	Max
Control (n=36)	47.9 (8.8)	59.5 (9.6)	11.6 (9.2)	38	78

Inferential Statistics

ANCOVA results indicated a statistically significant main effect of instructional condition on posttest analytical skill scores after controlling for pretest scores, $F(1, 69) = 23.74$, $p < .001$, partial $\eta^2 = 0.26$. Cohen's $d = 1.12$ indicated a large effect size. The experimental group's adjusted mean posttest score ($M = 72.3$, $SE = 1.4$) was significantly higher than the control group's adjusted mean ($M = 59.7$, $SE = 1.4$), a difference of 12.6 points. Box's M test confirmed homogeneity of covariance matrices ($p = .34$), and Levene's test indicated homogeneity of error variances ($p = .51$), satisfying ANCOVA assumptions.

Table 2. ANCOVA Results for Analytical Skill Posttest Scores

Source	SS	df	MS	F	p	η^2p
Pretest (covariate)	1842.3	1	1842.3	18.62	.000	.21
Instruction (treatment)	2349.1	1	2349.1	23.74	.000	.26
Error	6823.4	69	98.9	—	—	—
Total	11014.8	71	—	—	—	—

Qualitative Findings

Thematic analysis of student reflective journals yielded three primary themes: (1) Cultural familiarity as an analytical anchor, (2) Comparative thinking between cultural and formal scientific explanations, and (3) Increased metacognitive awareness. Representative excerpts illustrated how students used their knowledge of traditional boat construction to decompose the physics of buoyancy: 'When I look at how the tekong boat floats even though it is heavy, I started to think about what parts matter the shape, the material, the weight distribution and how each part works differently.' This excerpt exemplifies the differentiating cognitive process at the core of analytical skill. The theme of comparative thinking was particularly prominent, with students frequently contrasting cultural explanations with scientific models, a process that required them to organize and evaluate competing frameworks of understanding.

Discussion

The results of this study provide strong evidence that ethnoscience-based physics learning significantly enhances students' analytical skills compared to conventional instruction. The large effect size ($d = 1.12$) suggests that the integration of Malay cultural contexts into physics instruction produces educationally meaningful gains in analytical reasoning, not merely marginal improvements. These findings are consistent with and extend the growing body of literature on culturally responsive science pedagogy (Gay, 2000; Ladson-Billings, 1995; Kimmerer, 2013).

The mechanism underlying this effect appears to be multifaceted. First, as suggested by the qualitative findings and consistent with Vygotsky's (1978) sociocultural theory, cultural familiarity provides students with a cognitive anchor from which to exercise analytical operations. When students encounter physics phenomena embedded in contexts they know intimately such as the dynamics of traditional boat racing or the thermal properties of batik dyeing they can more readily apply the differentiating and organizing processes that define analytical thinking (Anderson & Krathwohl, 2001). This finding aligns with Aikenhead and Jegede's (1999) border-crossing framework: reducing the cognitive distance between students' cultural world and the scientific world of school enables deeper engagement with scientific content.

Second, the comparative thinking theme identified in student journals suggests that ethnoscience-based instruction promotes a distinctive analytical process: the evaluation of competing explanatory frameworks. When students are asked to compare traditional explanations of physical phenomena with scientific models, they must engage in higher-order attributing operations (Anderson & Krathwohl, 2001), discerning the assumptions and evidential bases of each framework. This type of epistemological analysis is rarely demanded by conventional physics instruction, which typically presents scientific knowledge as the sole valid explanatory resource. The present findings suggest that incorporating cultural knowledge as an explicit object of analytical comparison may be a particularly powerful mechanism for developing analytical skills in physics.

The increased metacognitive awareness reported by students in the experimental group also merits attention. Several studies have established that metacognitive monitoring is closely linked to analytical skill development, as it enables students to regulate their own cognitive processes and detect gaps in their understanding (Flavell, 1979; Schraw & Dennison, 1994). The ethnoscience-based instruction in this study may have fostered metacognition by making implicit cultural knowledge explicit and subject to critical examination a process that mirrors the analytical operations required in formal scientific reasoning.

These findings have important implications for the study of physics education in multicultural and postcolonial contexts. In Indonesia, where the national curriculum increasingly emphasizes the integration of local content (*muatan lokal*), the present results provide empirical support for the pedagogical value of ethnoscience-based approaches. Sudarmin et al. (2019) similarly found that ethnoscience-based chemistry instruction improved critical thinking in Central Java, suggesting that the benefits of this approach may generalize across science disciplines and cultural contexts in Indonesia. Furthermore, Wahab et al. (2019) demonstrated specific gains in physics conceptual understanding from Malay cultural contexts in West Kalimantan, and the present study extends those findings to the domain of analytical skills.

It is important to note several limitations of the present study. The quasi-experimental design, while appropriate given school scheduling constraints, cannot entirely rule out selection effects as alternative explanations for the observed differences. Although pretest scores did not differ significantly between groups and were controlled statistically, unmeasured individual characteristics (e.g., prior cultural knowledge, general analytical ability) may have influenced the results. Additionally, the study was conducted over a six-week period; longer-term effects on analytical skill retention and transfer to novel physics contexts remain unknown. Finally, the generalizability of the findings is limited to contexts with similar cultural and educational characteristics. Future research should employ randomized controlled designs, extended intervention periods, and cross-cultural replications to strengthen the evidence base for ethnoscience-based physics education.

CONCLUSION

This study demonstrated that ethnoscience-based physics learning, drawing on West Kalimantan Malay cultural practices, significantly enhances students' analytical skills compared to conventional instruction, with a large effect size ($d = 1.12$). Qualitative evidence suggests that cultural familiarity, comparative epistemological thinking, and enhanced metacognitive awareness are key mechanisms underlying this effect. These findings support the integration of local cultural knowledge into physics curricula as both a pedagogically effective and culturally affirming strategy. For curriculum developers, the results suggest that a systematic mapping of local cultural practices onto physics concepts can yield educationally powerful instructional contexts. For teacher educators, the findings underscore the importance of training physics teachers in ethnoscience pedagogy, including the facilitation of comparative cultural-scientific analysis. Future research should address the longterm and cross-contextual generalizability of ethnoscience-based physics instruction and explore its effects on other dimensions of scientific competence, including creativity and evaluative judgment.

REFERENCES

Aikenhead, G. S., & Jegede, O. J. (1999). Cross-cultural science education: A cognitive explanation of a cultural phenomenon. *Journal of Research in Science Teaching, 36*(3), 269-287. https://doi.org/10.1002/(SICI)1098-2736(199903)36:3<269::AID-TEA3>3.0.CO;2-T

Anderson, L. W., & Krathwohl, D. R. (Eds.). (2001). A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives. *Longman*.

Atran, S. (1990). Cognitive foundations of natural history: Towards an anthropology of science. *Cambridge University Press*.

Bang, M. and Medin, D. (2010), Cultural processes in science education: Supporting the navigation of multiple epistemologies. Sci. Ed., 94: 1008-1026. https://doi.org/10.1002/sce.20392

Bloom, B. S., Engelhart, M. D., Furst, E. J., Hill, W. H., & Krathwohl, D. R. (1956). Taxonomy of educational objectives: The classification of educational goals. Handbook I: Cognitive domain. *David McKay*.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77-101. https://doi.org/10.1191/1478088706qp063oa

Cobern, W. W., & Loving, C. C. (2001). Defining science in a multicultural world: Implications for science education. *Science Education, 85*(1), 50-67. https://doi.org/10.1002/1098-237X(200101)85:1<50::AID-SCE5>3.0.CO;2-G

Creswell, J. W. (2014). Research design: Qualitative, quantitative, and mixed methods approaches (4th ed.). *Sage Publications*.

Docktor, J. L., & Mestre, J. P. (2014). Synthesis of discipline-based education research in physics. *Physical Review Special Topics: Physics Education Research, 10*(2), 020119. https://doi.org/10.1103/PhysRevSTPER.10.020119

Flavell, J. H. (1979). Metacognition and cognitive monitoring: A new area of cognitive-developmental inquiry. *American Psychologist, 34*(10), 906-911. https://doi.org/10.1037/0003-066X.34.10.906

Gay, G. (2000). Culturally responsive teaching: Theory, research, and practice. Teachers College Press.

Harding, S. (1998). Is science multicultural? Postcolonialisms, feminisms, and epistemologies. *Indiana University Press*.

Hestenes, D., Wells, M., & Swackhamer, G. (1992). Force concept inventory. *The Physics Teacher, 30*(3), 141-158. https://doi.org/10.1119/1.2343497

Hmelo-Silver, C. E., Duncan, R. G., & Chinn, C. A. (2007). Scaffolding and achievement in problem-based and inquiry learning: A response to Kirschner, Sweller, and Clark. *Educational Psychologist, 42*(2), 99-107. https://doi.org/10.1080/00461520701263368

Kimmerer, R. W. (2013). Braiding sweetgrass: Indigenous wisdom, scientific knowledge, and the teachings of plants. Milkweed Editions.

Ladson-Billings, G. (1995). Toward a theory of culturally relevant pedagogy. *American Educational Research Journal, 32*(3), 465-491. https://doi.org/10.3102/00028312032003465

McKinley, E., & Stewart, G. (2012). Out of place: Indigenous knowledge in the science curriculum. In B. J. Fraser, K. Tobin, & C. J. McRobbie (Eds.), *Second international handbook of science education* (pp. 541-554). Springer.

Metz, D. (2011). Navigating a sea of tensions: Issues of equity in ethnoscience education. *Cultural Studies of Science Education, 6*(4), 891-903. https://doi.org/10.1007/s11422-011-9361-8

Schraw, G., & Dennison, R. S. (1994). Assessing metacognitive awareness. *Contemporary Educational Psychology, 19*(4), 460-475. https://doi.org/10.1006/ceps.1994.1033

Snively, G., & Corsiglia, J. (2001). Discovering indigenous science: Implications for science education. *Science Education, 85*(1), 6-34. https://doi.org/10.1002/1098-237X(200101)85:1<6::AID-SCE3>3.0.CO;2-R

Sudarmin, S., Febu, R., Nuswowati, M., & Sumarni, W. (2018). Development of ethnoscience approach in the chemistry learning context as a means of growing the scientific literacy of prospective teacher. *Journal of Physics: Conference Series, 1006*, 012031. https://doi.org/10.1088/1742-6596/1006/1/012031

Vygotsky, L. S. (1978). Mind in society: The development of higher psychological processes. *Harvard University Press*.