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Enhancing Critical Thinking through Ethnoscience-Integrated Problem-Based Learning: A Comparative Study in Secondary Education

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Abstract

This study investigates the impact of integrating ethnoscience with problem-based learning (PBL) on the enhancement of critical thinking skills among secondary school students. Employing a nonequivalent control group design with purposive sampling, the research involved 66 students from a Nigerian secondary school, divided into experimental (n=31) and control (n=35) groups. The experimental group engaged in a PBL curriculum enriched with ethnoscience, while the control group received traditional expository teaching. The study aimed to bridge the gap in current educational practices by incorporating cultural relevance into science education, thus making learning more meaningful and directly applicable to students' lives. Results indicated a significant improvement in the critical thinking abilities of the experimental group, as evidenced by their pretest and posttest scores, compared to the control group. The findings underscore the effectiveness of the ethnoscience-integrated PBL approach in fostering higher-order thinking skills, suggesting a notable advancement over conventional teaching methods. This research contributes to the educational literature by demonstrating the benefits of combining ethnoscience and PBL, advocating for a shift towards more dynamic, student-centered, and culturally relevant teaching strategies. The study highlights the importance of contextual learning experiences and suggests further exploration across various disciplines and educational levels to validate the approach's effectiveness and applicability.

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INTRODUCTION

Education today goes beyond the simple acquisition of textbook knowledge, placing a strong emphasis on the development of comprehensive cognitive skills among students. This approach is particularly pertinent as we navigate the complexities and challenges of the 21st century. Critical thinking, as highlighted by researchers like Salvetti et al. (2023) and Altun and Yildirim (2023), emerges as a fundamental skill that students must master to succeed in this dynamic era. The global curriculum reflects this need, emphasizing the vital role of critical thinking in both the academic and eventual professional success of students. This focus underscores the importance of not just acquiring knowledge, but also developing the ability to critically evaluate and apply this knowledge effectively.

However, the process of nurturing critical thinkers is intricate and demands a strategic educational framework. It is widely recognized that critical thinking skills do not develop overnight; they require careful cultivation through specific educational practices (Aliyu et al., 2023; Bilad, Doyan, et al., 2022). Unfortunately, current science education often overlooks the critical component of socio-cultural context, leading to a gap in students' ability to apply scientific concepts in real-life situations. This disconnect stems from a teaching paradigm that fails to integrate science with everyday life and cultural values, as noted by Zidny et al. (2020). Such oversight can hinder the relevance and impact of science education, making it imperative to weave local wisdom and cultural insights into the curriculum to enhance learning outcomes.

The importance of integrating socio-scientific and cultural contexts into science education cannot be overstated. According to Sjöström et al. (2016), a contemporary science education should acknowledge and incorporate diverse socio-scientific issues and cultural knowledge, termed "indigenous knowledge" by Zidny et al. (2020). This approach allows students to connect their personal and communal knowledge bases with scientific concepts, fostering a more holistic understanding of science. By comparing and contrasting their beliefs, values, and experiences with modern scientific ideas, students can achieve a deeper comprehension and appreciation of science. This method not only makes science more accessible but also more relevant to students' lives, encouraging a more engaged and enthusiastic approach to learning.

However, the challenge remains in effectively integrating these principles into science education. The current educational system, which often neglects pre-existing cultural beliefs, may inadvertently reduce students' interest in science and negatively impact their understanding and attitudes towards scientific learning (Alshammari et al., 2015). The disconnection between cultural relevance and scientific education has been shown to adversely affect students' critical thinking skills (Prayogi et al., 2022). It is, therefore, crucial to adopt teaching strategies that bridge this gap, ensuring that science education is both culturally relevant and conducive to developing critical thinking skills.

To this end, problem-based learning (PBL) emerges as a powerful pedagogical model that can address these challenges. PBL places students at the center of the learning process, engaging them in active problem-solving and collaborative learning. This model fosters a deep engagement with real-world problems, encouraging students to apply their knowledge in practical contexts (Pozuelo-Muñoz et al., 2023; Smith et al., 2022; Marcinauskas et al., 2024). Such an approach not only enhances students' critical thinking abilities but also ensures that learning is meaningful and directly applicable to their lives. By embracing PBL and other dynamic educational models, educators can cultivate a generation of critical thinkers who are well-equipped to navigate the challenges of the 21st century.

Current Study Context, Aims and Research Questions

Education plays a pivotal role in cultivating individuals of high caliber, with the enhancement of critical thinking skills being a focal point in the educational process. However, within the current educational landscape, challenges must be addressed regarding the effectiveness of the employed teaching models. Among these, Problem-Based Learning (PBL) has garnered attention for its emphasis on challenging students to solve problems through collaboration and problem-solving. While PBL holds the promise of fostering critical thinking skills, there's a recognized need to weave local and cultural elements into the learning process. Consequently, this study highlights the significance of integrating ethnosciences into PBL. This integration combines traditional knowledge with modern scientific understanding, crafting a learning context that is both relevant and meaningful for students. Ethnoscience, which transforms indigenous knowledge into scientific understanding, and the introduction of local wisdom into the classroom, can reflect the diverse cultural backgrounds of students, potentially enriching their interpretation of knowledge (Botha, 2012). This approach could make science education more relevant to students in culturally diverse classrooms (De Beer & Whitlock, 2009). The current study anticipates that incorporating ethnosciences into the learning process will enhance students' critical thinking skills.

Despite efforts to merge PBL with ethnosciences, there's a paucity of in-depth research on its impact on students' critical thinking skills. Thus, further investigation is warranted to understand the actual effects of this educational model on the development of students' critical thinking abilities. This research aims to bridge the existing knowledge gap and provide deeper insights into how the integrated PBL and ethnosciences model influences students' critical thinking skills. The findings of this study are expected to contribute to the development of more effective learning strategies for enhancing students' critical thinking skills in the contemporary educational era. Specifically, the research questions are as follows:

1. What is the impact of the integrated problem-based learning and ethnosciences model on students' critical thinking skills?
2. How do the critical thinking skills of students taught through the integrated problem-based learning and ethnosciences model compare with those taught through traditional expository teaching methods?

METHODS

Research Design

The research adopted a nonequivalent control group design, employing two groups: a control group and an experimental group selected through non-probability, purposive sampling. This sampling method involves choosing participants based on specific characteristics or qualities known in advance, aiming for targeted insights. Both groups were exposed to the same learning materials but underwent different learning treatments, as outlined in the Table 1.

Table 1. Research Design

Groups	Pretest	Treatment	Posttest
Experimental	O_1	X	O_2
Control	O_1	Y	O_2

The experimental group engaged with a problem-based learning (PBL) model integrated with ethnosciences (X), whereas the control group experienced traditional expository teaching (Y). A pretest (O_1) was administered to both groups before the treatment, and a posttest (O_2) followed the treatment. The study spanned two months, focusing on physics science subjects. Ensuring consistency in timing for pretests, interventions, and posttests between groups was crucial to minimize external variability and accurately attribute measured changes to the intervention. Careful time management and maintaining similar conditions for both groups during the study aimed to reduce bias and enhance the validity of the research findings.

Sample and Ethical Consideration

The study was conducted in a secondary school in Nigeria, involving sixty-six students divided into an experimental group (n = 31) and a control group (n = 35). Demographically, participants were aged between 15 to 16 years, with a relatively balanced gender distribution. However, the study did not consider the demographic backgrounds of the sample as influencing variables.

Ethical approval was obtained from the relevant ethics committee and educational institution, ensuring all activities adhered to ethical standards. Participant anonymity and data confidentiality were prioritized, with minimized psychological risks and clarified voluntary participation, allowing students to withdraw at any time without consequences.

Procedure

The research commenced with purposive sampling of students, dividing them into experimental and control groups. Before implementing the learning methods, both groups took a pretest assessing their initial critical thinking skills, measuring abilities in analysis, inference, evaluation, and decision-making. Subsequently, each group received specific treatments over two months, with educational content focusing on physics science subjects. After the intervention period, a posttest assessed the change in students' critical thinking skills resulting from the different educational treatments. The instruments for pretests and posttests were previously validated and adapted to a critical thinking scoring scale. Research findings were then analyzed to draw conclusions.

Instruments and Analysis

Students' critical thinking skills were measured using a test instrument featuring indicators for analysis, inference, evaluation, and decision-making. This instrument, already validated, was deemed suitable for collecting critical thinking data as pretests and posttests. The critical thinking scoring system was adapted from the Ennis-Weir Critical Thinking Essay Test, with a modified scoring scale. The critical thinking criteria ranged from non-critical to highly critical (Aliyu et al., 2023). Data on students' critical thinking skills were analyzed descriptively and statistically. Descriptive data analysis focused on average critical thinking scores and improvements from pretest to posttest. Score improvements were calculated using Hake's (1999) formula. Statistical data analysis involved difference tests (t-tests) preceded by prerequisite tests (normality and homogeneity tests), particularly to test research hypotheses at a 0.05 significance level, using SPSS 22.0 software.

RESULTS AND DISCUSSION

A study was conducted with the objective of examining the impact of an integrated problem-based learning model with ethnosciences on students' critical thinking skills. The analysis of the experimental class's descriptive results, focusing on the average scores of critical thinking and the normalized gain (n-gain) for each indicator, is detailed in Table 2 and Figure 1. This approach aimed to provide a comprehensive understanding of how the innovative teaching method influences the development of critical thinking abilities among students.

Table 2. Results of descriptive analysis of the critical thinking skills of the experimental group

Indicator	N	Pretest			Posttest			n-gain	Criteria
		Min	Max	Mean (SD)	Min	Max	Mean (SD)		
Analysis	31	0.00	3.00	1.77 (±0.85) (Quite Critical)	1.50	3.00	2.39 (±0.84) (Critical)	0.48	Moderate
Inference	31	0.00	2.50	0.68 (±0.65) (Less Critical)	1.50	3.00	2.34 (±0.85) (Critical)	0.72	High
Evaluate	31	0.00	1.50	0.05 (±0.46) (Not Critical)	1.50	3.00	2.33 (±080) (Critical)	0.73	High
Decision-making	31	0.00	1.50	0.72 (±0.45) (Less Critical)	1.50	3.00	2.39 (±0.86) (Critical)	0.78	High

The results presented in Table 2 and Figure 1 illustrates the impact of an integrated problem-based learning model with ethnosciences on the critical thinking skills of students in an experimental group. The table reports on four critical thinking indicators: Analysis, Inference, Evaluate, and Decision-making, with each indicator assessed among 31 students through pretest and posttest scores, alongside calculated normalized gains (n-gain). Initially, for the Analysis indicator, students' scores ranged from 0.00 to 3.00 in the pretest, with an average score of 1.77 (±0.85), categorized as Quite Critical. Post-intervention, the scores improved to a range of 1.50 to 3.00 with an average of 2.39 (±0.84), elevating to Critical, and an n-gain of 0.48, indicating moderate improvement. Similarly, Inference started with scores between 0.00 to 2.50, averaging at 0.68 (±0.65), considered Less Critical, and posttest scores rose to a 1.50 to 3.00 range with an average of 2.34 (±0.85), achieving a Critical status with a high n-gain of 0.72.

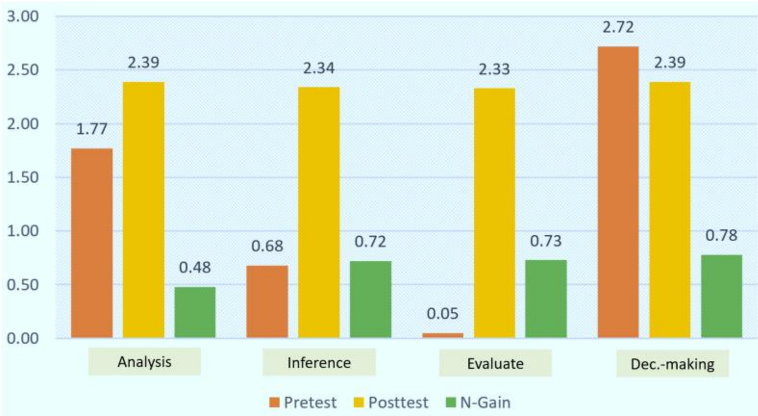

Figure 1. Visualization of the results of descriptive analysis of the critical thinking skills of the experimental group

For the Evaluate indicator, initial scores were significantly low, ranging from 0.00 to 1.50 with a mean of merely 0.05 (±0.46), classified as Not Critical. After the intervention, scores significantly increased to a range of 1.50 to 3.00 with an average of 2.33 (±0.80), reaching a Critical status and an n-gain of 0.73, reflecting a high level of improvement. Lastly, the Decision-making scores also demonstrated a substantial increase from a pretest range of 0.00 to 1.50 and a mean of 0.72 (±0.45), deemed Less Critical, to a posttest range of 1.50 to 3.00 and an average of 2.39 (±0.86), categorized as Critical, with the highest n-gain of 0.78, indicating a high level of enhancement in students' critical thinking ability. These results underscore the effectiveness of integrating problem-based learning with ethnosciences in fostering critical thinking skills among students, showing significant advancements across all measured indicators. Next, the results of the descriptive analysis of the control class based on the parameters of the average critical thinking score and n-gain for each indicator are presented in Table 3 and Figure 2.

Table 3. Results of descriptive analysis of the critical thinking skills of the control group

Indicator	N	Pretest			Posttest			n-gain	Criteria
		Min	Max	Mean (SD)	Min	Max	Mean (SD)		
Analysis	35	0.00	3.00	1.48(±0.85) (Quite Critical)	1.00	2.50	1.86(±0.45) (Quite Critical)	0.48	Moderate
Inference	35	0.00	2.00	0.63(±0.55) (Less Critical)	0.00	2.50	1.62(±0.46) (Quite Critical)	0.54	Moderate

Indicator	N	Pretest			Posttest			n-gain	Criteria
		Min	Max	Mean (SD)	Min	Max	Mean (SD)		
Evaluate	35	0.00	2.00	1.07(±0.57) (Less Critical)	0.50	2.00	1.42(±0.68) (Quite Critical)	0.30	Moderate
Decision-making	35	0.00	1.50	0.65(±0.58) (Not Critical)	0.00	2.00	1.14(±0.58) (Quite Critical)	0.22	Low

Table 3 and Figure 2 reveals the outcomes of the descriptive analysis for the control group, which was subjected to traditional expository teaching methods, in terms of their critical thinking skills. The analysis encompassed four indicators: Analysis, Inference, Evaluate, and Decision-making, with assessments conducted among 35 students through pretest and posttest scores, along with the computed normalized gains (n-gain). For the Analysis indicator, initial scores varied from 0.00 to 3.00, with an average of 1.48 (±0.85), qualifying as Quite Critical. Following the intervention, scores increased to a range between 1.00 to 2.50 with an average of 1.86 (±0.45), remaining in the Quite Critical category, and an n-gain of 0.48, indicating moderate improvement. In the case of Inference, the pretest scores ranged from 0.00 to 2.00, averaging 0.63 (±0.55), considered Less Critical, which then improved to a range of 0.00 to 2.50 with an average of 1.62 (±0.46), moving up to Quite Critical with a moderate n-gain of 0.54.

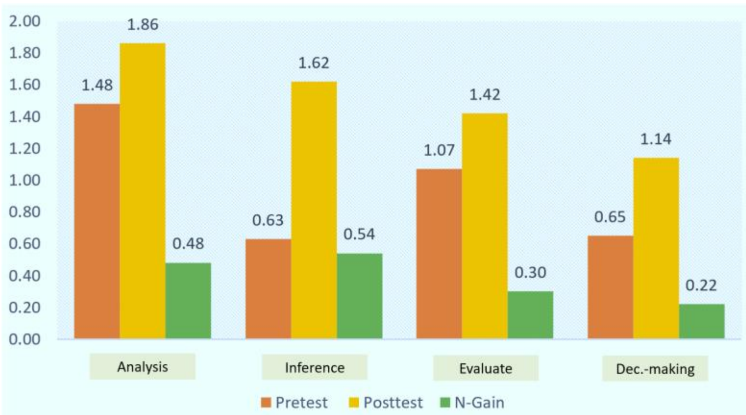

Figure 2. Visualization of the results of descriptive analysis of the critical thinking skills of the control group

On the Evaluate indicator, the control group began with scores ranging from 0.00 to 2.00, with a mean of 1.07 (±0.57), labeled as Less Critical. After the intervention, these scores modestly increased to between 0.50 and 2.00 with an average of 1.42 (±0.68), achieving a Quite Critical status, accompanied by an n-gain of 0.30, which is considered moderate. The Decision-making scores showed a pretest range from 0.00 to 1.50 with an average of 0.65 (±0.58), categorized as Not Critical. The posttest scores observed a slight increase to a range of 0.00 to 2.00 with an average of 1.14 (±0.58), elevating to Quite Critical, yet with a low n-gain of 0.22. These findings demonstrate the control group's moderate enhancement in critical thinking skills across most indicators, highlighting a less significant improvement compared to the experimental group, especially in decision-making capabilities. This underlines the potential added value of integrating problem-based learning with ethnosciences in promoting more substantial growth in critical thinking skills. Furthermore, the results of descriptive analysis based on the average total score of classical critical thinking in the experimental and control groups are presented in Table 4.

Table 4. The results of the descriptive analysis are based on the average total score of classical critical thinking in the experimental and control groups

Group	N	Pretest			Posttest			n-gain	Criteria
		Min	Max	Mean	Min	Max	Mean		
Experimental	31	3.00	9.00	6.55	15.00	23.00	18.68	0.70	Moderate
Control	35	5.00	11.00	7.66	10.00	15.00	12.11	0.27	Low

Table 4 provides a comparative overview of the average total scores for classical critical thinking skills between the experimental and control groups, both before and after the intervention, alongside the calculated normalized gains (n-gain). In the experimental group, which utilized an integrated problem-based learning approach with ethnosciences, the pretest scores ranged from 3.00 to 9.00, with an average score of 6.55. Post-intervention, this group showed a significant improvement in their critical thinking scores, with the range expanding to 15.00 to 23.00 and the average score increasing to 18.68. This substantial increase resulted in a normalized gain of 0.70, which is categorized as moderate. This indicates a notable enhancement in the critical thinking abilities of students exposed to the innovative teaching methodology, reflecting the effectiveness of combining problem-based learning with ethnosciences in fostering critical thinking skills.

Conversely, the control group, which was taught using traditional expository methods, started with pretest scores between 5.00 to 11.00, averaging at 7.66. After the intervention, their posttest scores ranged from 10.00 to 15.00, with an average increase to 12.11. The normalized gain for the control group was calculated at 0.27, indicating a low level of improvement in critical thinking skills. This contrast between the experimental and control groups' outcomes highlights the relative efficacy of the problem-based learning model integrated with ethnosciences. The experimental group's students not only achieved higher average scores but also demonstrated a greater increase in their ability to think critically, underscoring the potential of innovative educational strategies to significantly enhance critical thinking skills compared to more traditional teaching approaches. Furthermore, differences in students' critical thinking skills scores between classes were tested statistically, preceded by normality and homogeneity tests. The results of the normality and homogeneity tests are presented in Table 5.

Table 5. Normality and homogeneity test results

Group	Score	N	Normality			Homogeneity	
			Mean	SD	Sig.	Levine test	Sig.
Experimental	Pre-test	31	6.65	2.027	0.217	8.196	0.066
	Post-test	31	18.68				
Control	Pre-test	35	7.66	1.272	0.311		
	Post-test	35	12.11				

The results from Table 5, showing the normality and homogeneity tests for critical thinking scores of students in both experimental and control groups, indicate that the data meets the necessary assumptions for subsequent statistical analysis. For the experimental group's pre-test scores, with a mean of 6.65 and a standard deviation of 2.027, the normality test returned a significance value of 0.217, suggesting a normal distribution. Similarly, the control group's pre-test scores, with a mean of 7.66 and a standard deviation of 1.272, showed a normality significance value of 0.311, further confirming normal distribution. The Levine test for homogeneity yielded a significance value of 0.066, indicating homogeneous variances across groups. These results validate the data's adherence to the prerequisites for statistical comparison, setting the stage for analyzing differences in critical thinking improvements between the experimental and control groups. Based on these results, a paired sample t-test was carried out ($p < 0.05$), the results are presented in Table 6.

Table 6. Paired sample t-test results ($p < 0.05$)

Pair	Group	N	Mean	SD	t	df	p
Pair 1	Exp. (pretest)	31	-12.129	2.125	-31.778	30	0.000
	Exp. (posttest)	31					
Pair 2	Cont. (pretest)	35	-4.343	1.679	-15.299	34	0.000
	Cont. (posttest)	35					

The statistical analysis presented in Table 6, utilizing the paired sample t-test, assesses the impact of educational interventions on two distinct groups: the experimental and the control groups, with the analysis predicated on a significance threshold of $p < 0.05$. The experimental group, denoted as Pair 1, underwent a pretest and posttest evaluation, revealing a marked improvement in their scores from -12.129 in the pretest to -31.778 in the posttest, yielding a statistically significant p-value of 0.000. This substantial shift underscores the experimental group's considerable progress post-intervention. Meanwhile, the control group, or Pair 2, also demonstrated significant growth from their pretest to posttest scores, moving from -4.343 to -15.299 with a p-value of 0.000. Although the control group saw noteworthy improvements, their advancements were not as pronounced as those observed in the experimental group. This difference validates the hypothesis that the problem-based learning model, when integrated with ethnosciences, significantly bolsters students' critical thinking capabilities, casting traditional expository teaching methods as less effective in fostering these essential skills.

This comparative analysis not only validates the effectiveness of the problem-based learning approach integrated with ethnosciences but also highlights the limitations of conventional teaching strategies in nurturing critical thinking among students. The experimental group's significant leap in performance post-intervention, as opposed to the more modest gains seen in the control group, speaks volumes about the added value of innovative teaching methodologies. By affirming the research hypothesis, the study emphasizes the substantial influence that a problem-based learning framework, enriched with ethnoscientific knowledge, has on the critical thinking development of students. This revelation underscores the necessity for educational practices to evolve beyond traditional methods to cultivate the analytical and evaluative skills that students need in an increasingly complex world.

The recent study illuminates the profound effect that integrating ethnoscience into a problem-based learning (PBL) framework has on enhancing students' critical thinking capabilities. PBL, recognized for its student-centric approach, stimulates active participation, teamwork, and problem-solving initiatives (Aliyu et al., 2023). Meanwhile, ethnoscience enriches the curriculum by embedding cultural knowledge, thereby amplifying the relevance of the context in which learning occurs (Koirala, 2023). The synergy of these methodologies is designed to create an all-encompassing educational setting that not only imparts specialized knowledge across various subjects but also advances the critical thinking skills of students, aligning perfectly with the objectives of this investigation.

This research has demonstrated a notable positive impact on the critical thinking abilities of students, substantiated by the significant findings from the paired samples t-test detailed in Table 6. There was a marked enhancement in the critical thinking skills among members of the experimental group, as evidenced by the considerable differences between their pretest and posttest scores. Such findings are in harmony with earlier studies that have validated the efficacy of PBL in fostering advanced cognitive skills, particularly in the realm of critical thinking (Suhirman & Ghazali, 2022). PBL's emphasis on exploratory learning, wherein scientific inquiry plays a pivotal role, has been shown to not only bolster cognitive skills but also positively affect a broader array of educational outcomes, echoing the insights of prior research (Biazus & Mahtari, 2022; Bilad, Anwar, et al., 2022). These recent observations align with Marcinauskas et al. (2024), who concluded that PBL surpasses traditional instructional methods in promoting more engaging and effective classroom learning experiences. The integration of ethnoscience into this pedagogical strategy further augments its impact by incorporating cultural contexts, thereby encouraging learners to employ critical thinking from varied viewpoints (Prayogi et al., 2022).

A critical element underscored by this study is the enriched learning experience brought about by the integration of ethnoscience, affirming the principle that learning achieves its greatest impact when conducted within contexts that resonate with the learners' own cultural backgrounds. By weaving ethnoscience with PBL, the curriculum's cultural relevance is significantly enhanced, bridging theoretical concepts with their practical applications in the real world, deeply rooted in students' cultural heritage. This method not only facilitates a deeper comprehension of the material but also significantly contributes to the cultivation of critical thinking skills among students. Such an approach has been corroborated by preceding studies, which have highlighted the success of combining PBL with ethnoscience in elevating critical thinking skills across different educational settings (Prayogi et al., 2022).

In conclusion, this investigation adds to the accumulating evidence that supports the dynamic and effective nature of integrating ethnoscience with problem-based learning. This blend not only addresses the need for subject-specific knowledge but also fosters essential skills vital for thriving in a range of academic and professional settings. The findings advocate for a shift towards educational strategies that are not just focused on content delivery but are also aimed at developing comprehensive skill sets, including critical thinking, which are indispensable in navigating the complexities of the modern world. Through such integrated educational frameworks, students are better prepared to face the challenges of an ever-evolving global landscape, underscoring the importance of innovative teaching methods in today's diverse educational ecosystem.

CONCLUSION

This study's findings significantly contribute to the existing literature by demonstrating the positive impact of integrating ethnoscience with a problem-based learning (PBL) approach on enhancing students' critical thinking skills. The PBL model, renowned for its focus on student-centered learning, active engagement, and problem-solving, was further enriched by incorporating ethnoscience, which adds cultural knowledge into the learning, thereby increasing its contextual relevance. This unique blend not only promoted subject-specific knowledge but also significantly improved students' critical thinking abilities. The empirical evidence, highlighted by the substantial improvements in the experimental group's critical thinking scores compared to the control group, underscores the effectiveness of this innovative teaching method. It reaffirms the hypothesis that integrating problem-based learning with ethnoscience is more effective in fostering critical thinking skills than traditional expository teaching methods.

Moreover, the study illuminates the importance of contextual learning experiences facilitated by the integration of ethnoscience. This approach, which aligns learning with students' cultural backgrounds, not only deepens their understanding but also significantly enhances their critical thinking capabilities. The comparison of pretest and posttest scores within the experimental group reveals a noteworthy advancement in critical thinking, demonstrating the added value of this pedagogical strategy. These findings advocate for a paradigm shift in educational practices towards more dynamic and culturally relevant teaching methods, highlighting the necessity for educational strategies that not only focus on content knowledge but also prioritize the development of critical thinking and other essential skills for success in diverse academic and professional environments.

LIMITATION

A notable limitation of this study is its reliance on a non-equivalent control group design and purposive sampling, which may influence the generalizability of the findings. The selection of participants based on specific characteristics, without random assignment to experimental and control groups, could introduce selection bias, potentially affecting the outcomes. Additionally, the study's focus on a single educational context and a specific subject area (physics science) may limit the applicability of its conclusions to other disciplines or educational settings. Future research should consider employing a more diverse sample and a randomized controlled trial design to enhance the validity and generalizability of the results.

RECOMMENDATION

Given the promising results of integrating ethnoscience with problem-based learning, future research should explore this pedagogical approach across various disciplines and educational levels to validate its effectiveness in enhancing critical thinking skills. It would be beneficial to investigate the long-term impact of this teaching method on students' academic and professional success, including studies that track participants' progress beyond the classroom. Additionally, further research could examine the role of teacher training and support in effectively implementing this innovative teaching strategy, ensuring educators are well-equipped to integrate cultural knowledge and problem-based learning into their curricula.

Author Contributions

The authors have sufficiently contributed to the study, and have read and agreed to the published version of the manuscript.

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Conflict of interests

The authors declare no conflict of interest.

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