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The Effects of Ethnoscience Integrated Problem-Based Learning Models on Students' Critical Thinking Skills

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Abstract

In the contemporary educational landscape, cultivating critical thinking skills is imperative for students to thrive in the 21st century. Recognizing that critical thinking is not an instantaneous process, it is essential to employ didactic mechanisms specifically designed to hone this skill. Traditional expository teaching methods have been deemed insufficient in fostering critical thinking among students. Therefore, effective pedagogical intervention models are warranted, allowing students to engage authentically in everyday contexts. This study assesses the impact of an ethnoscience-integrated problem-based learning model on students' critical thinking skills. Employing a quasi-experimental design with a non-equivalent control group, the research unfolded in a secondary school in Mataram City, with a sample of 66 students divided into experimental and control classes. The experimental class experienced instruction through an ethnoscience-integrated problem-based learning model, while the control class adhered to traditional (expository) teaching methods. Critical thinking skills were assessed using a validated test instrument encompassing analysis, inference, evaluation, and decision-making indicators. Descriptive and statistical analyses were applied to scrutinize the data. The results revealed that students in the experimental class exhibited higher levels of critical thinking skills than their counterparts in the control class, which was statistically significant. In conclusion, this research establishes a significant positive influence of the ethnoscience-integrated problem-based learning model on students' critical thinking skills. Furthermore, it reaffirms the inadequacy of traditional (expository) teaching in enhancing students' critical thinking abilities.

Keywords: Problem-based learning model, ethnoscience, critical thinking

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INTRODUCTION

Education extends beyond the mere mastery of learning materials; it necessitates the development of cognitive skills, including crucial social competencies essential for addressing diverse challenges (Salvetti et al., 2023; Haryanti, 2017). Within the contemporary landscape, the acquisition of critical thinking skills is paramount for navigating the complexities of the 21st century (Defiyanti & Sumarni, 2020). The prevailing curriculum in Indonesia underscores the significance of cultivating critical thinking skills, as it indicates students' ability to analyze information judiciously (Falah & Windyariani, 2018). These skills play a pivotal role in shaping students' future career success by enabling them to scrutinize information in alignment with their existing knowledge base. However, the development of critical thinking is not instantaneous; it demands a didactic mechanism tailored to specifically nurture this cognitive skill (Aliyu et al., 2023; Bilad, Doyan, et al., 2022; Ekayanti et al., 2022).

The current deficiency in students' critical thinking proficiency is attributed to the oversight within science education, neglecting the socio-cultural environment that students inhabit. Furthermore, the failure to bridge science concepts with real-life applications exacerbates this issue, as teaching lacks a focus on principles that facilitate the integration of scientific knowledge into daily experiences (Temuningsih et al., 2017). Recognizing the potential of local wisdom values in community settings, there is a call to incorporate these values into science education to imbue learning with greater meaning (Prayogi et al., 2022). The study of local wisdom values, aligned with the context of science learning, is identified with the emerging field of ethnoscience (Verawati, Harjono, et al., 2022).

Critical thinking demands active student engagement in analyzing and solving real-world problems, including those encountered in their learning journey (Bilad, Anwar, et al., 2022). Characterized by the ability to compare external information with existing knowledge, critical thinking encourages students to pose questions and seek explanations for discrepancies or similarities. Recognized as a fundamental intellectual capital, critical thinking is deemed indispensable for everyone (Amri, 2015). Acknowledging that its cultivation is gradual, pedagogical interventions are crucial to stimulate and mold students' critical thinking abilities. In the context of science education, effective pedagogical models should encourage authentic exploration within the framework of everyday life, with problem-based learning (PBL) emerging as a dynamic and foundational approach (Fitriani et al., 2022; Suhirman & Prayogi, 2023; Suhirman & Ghazali, 2022).

Problem-based learning represents a student-centric, active learning model involving students in solving problems (Gultom & Adam, 2018). Previous studies attest to the efficacy of the PBL model in fostering student engagement during the learning process, allowing them to independently seek information and collaborate in groups, thereby enhancing the meaningfulness of the learning experience and stimulating critical thinking (Sari et al., 2019; Nofziarni et al., 2019). This learning approach is designed to address practical problems in a real-world context, with the overarching goal of nurturing students' thinking, problem-solving, and intellectual abilities.

Context and Purpose of Study

Education plays a pivotal role in shaping well-rounded individuals, and cultivating critical thinking skills is a central objective in the learning journey. Despite this, the current educational landscape grapples with challenges related to the efficacy of prevailing learning models. One pedagogical approach that has garnered attention is Problem-Based Learning (PBL), which emphasizes collaborative problem-solving. While PBL holds promise for enhancing critical thinking, integrating local and cultural nuances remains imperative. This research underscores the significance of incorporating ethnoscience into PBL, a fusion of traditional and modern scientific knowledge, to establish a more pertinent and meaningful learning environment. Ethnoscience, the transformation of societal knowledge into scientific science, serves as a conduit to preserve and nurture local wisdom and culture, potentially amplifying students' scientific literacy based on previous studies (Falah & Windyariani, 2018; Agustin et al., 2018).

Despite some attempts to fuse PBL with ethnoscience, there exists a paucity of in-depth research exploring its impact on students' critical thinking skills. Consequently, further investigation is warranted to comprehensively grasp the true influence of this integrated learning model on critical thinking development. Against this backdrop, this research endeavors to bridge existing knowledge gaps and further comprehend how the amalgamation of PBL models with ethnoscience shapes students' critical thinking skills. The anticipated outcomes of this study aim to contribute valuable insights to the refinement of learning strategies, striving for enhanced critical thinking skills amidst the complexities of contemporary education.

In conclusion, education's role in molding individuals is paramount, specifically in nurturing critical thinking skills. Amidst challenges in the current educational paradigm, Problem-Based Learning (PBL) has emerged as a notable approach, highlighting collaborative problem-solving. However, integrating local and cultural elements is crucial for its effectiveness. This research advocates for the infusion of ethnoscience into PBL, a harmonious blend of traditional and modern scientific knowledge. Ethnoscience, as a vehicle for transforming societal knowledge into scientific science, holds the potential to preserve and promote local wisdom and culture, subsequently enhancing students' scientific literacy. Despite initial efforts, there remains a dearth of comprehensive research on the impact of PBL integrated with ethnoscience on critical thinking skills. Thus, this study aims to fill existing knowledge gaps, offering a nuanced understanding of how this integrated approach influences students' critical thinking skills, with the ultimate goal of contributing to more effective learning strategies in contemporary education.

METHOD

The chosen research design for this study was the nonequivalent control group design, which involves using two distinct classes: the control and experimental classes. These classes were selected based on non-probability sampling, specifically purposive sampling. Purposive sampling

is a deliberate method that takes into account specific considerations or objectives, relying on predetermined characteristics or traits. Both classes were provided with identical learning materials regarding effort and energy expenditure. However, the key distinction lies in the learning treatments each class received. The experimental class was exposed to an innovative approach, employing an ethnoscience-integrated problem-based learning model denoted as X, while the control class adhered to a traditional (expository) teaching method denoted as Y. The details of this research design are outlined in Table 1.

Table 1 illustrates the structured approach employed in the research design, showcasing the deliberate allocation of classes and the differentiated teaching methods. The nonequivalent control group design and purposive sampling serve as the foundation for this study's methodology. The juxtaposition of the experimental and control classes allows for a comprehensive examination of the impact of the ethnoscience-integrated problem-based learning model compared to the traditional teaching approach. This research design aims to contribute valuable insights into the effectiveness of different teaching methods and their implications for the participants' learning outcomes.

Table 1. Research design

Group/class	Pretest	Treatment	Posttest
Exprimental	O_1	X	O_2
Control	O_1	Y	O_2

The study was conducted within a secondary school in Mataram City - Indonesia, with a total sample size of 66 students. These students were systematically divided into two groups: an experimental class of 31 students and a control class of 35 students. Prior to any interventions, a pretest (O_1) was administered to both groups and subsequently, a posttest (O_2) was conducted after the treatment. The demographic characteristics, such as age and gender, were not considered during the research, as they were deemed non-influential variables.

Evaluating students' critical thinking skills employed a validated test instrument encompassing indicators like analysis, inference, evaluation, and decision-making. This instrument, already established as suitable for collecting critical thinking data in pretest and posttest scenarios, drew inspiration from the Ennis-Weir Critical Thinking Essay Test. The scoring system for critical thinking skills was adapted with modifications to the scale, ranging from not critical to very critical, as per the work of Prayogi et al. (2018).

Descriptive and statistical analyses were employed to interpret the data on students' critical thinking skills. Descriptively, the analysis focused on parameters such as students' average critical thinking scores and the observed increase in critical thinking scores from pretest to posttest. The scoring improvement was computed based on Hake's (1999) formulation. The statistical analysis incorporated a difference test (t-test), which was preceded by necessary prerequisite tests, including assessments of normality and homogeneity. This comprehensive approach aimed to test the research hypothesis, distinguishing between Ha (indicating a significant influence) and Ho (indicating no significant influence), with testing conducted at a significance level of 0.05 using SPSS 22.0 tools.

In essence, the research methodology encompassed a systematic division of students, the application of validated test instruments, and a meticulous, analytical approach to gauge the impact of the implemented treatment on students' critical thinking skills.

RESULTS AND DISCUSSION

Research has been conducted that aims to analyze the effect of the ethnoscience-integrated problem-based learning model on students' critical thinking skills. Analysis of the descriptive results of the experimental class based on the parameters of the average critical thinking score and n-gain for each indicator is presented in Table 2 and Figure 1.

Table 2. The results of descriptive analysis of experimental class critical thinking skills based on the average indicator score and n-gain parameters.

Indicator	N	Pretest			Posttest			n-gain	Criteria
		Min	Max	Mean (SD)	Min	Max	Mean (SD)		
Interpretation	31	0.00	3.00	1.77(±0.85) (enough critical)	1.50	3.00	2.39(±0.84) (critical)	0.48	Moderate
Analysis	31	0.00	2.50	0.68(±0.65) (less critical)	1.50	3.00	2.34(±0.85) (critical)	0.72	High
Inference	31	0.00	1.50	0.05(±0.46) (not critical)	1.50	3.00	2.33(±080) (critical)	0.73	High
Evaluate	31	0.00	1.50	0.72(±0.45) (less critical)	1.50	3.00	2.39(±0.86) (critical)	0.78	High

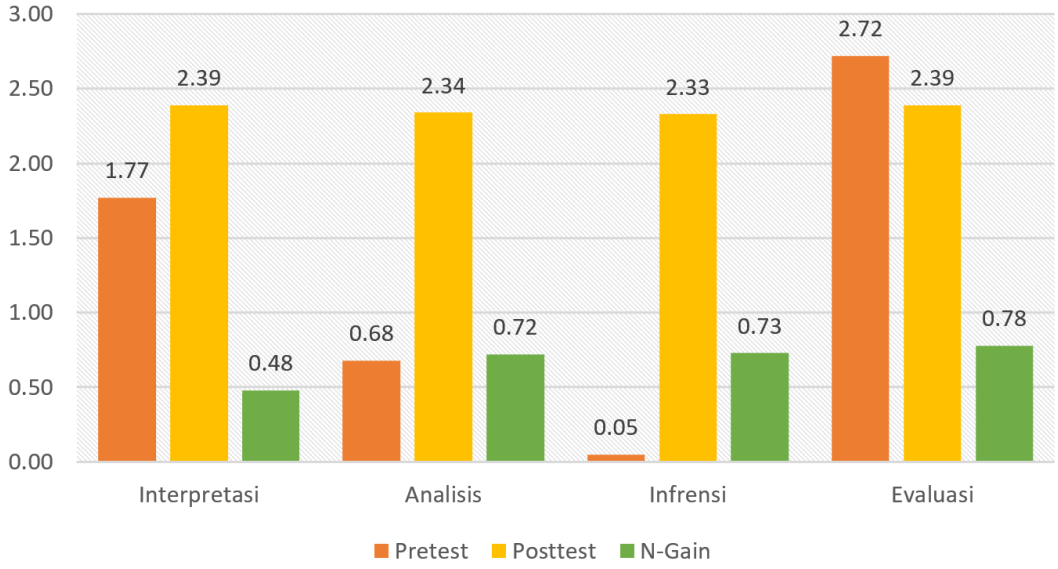

Figure 1. Illustrating the outcomes derived from a descriptive analysis of critical thinking skills within the experimental group. This presentation is grounded in both the average indicator score and n-gain parameters.

Table 2 and Figure 1 present the outcomes derived from the descriptive analysis conducted on the critical thinking skills of the experimental class, utilizing the parameters of average indicator score and n-gain. The Interpretation indicator showcased a noteworthy improvement in critical thinking skills among participants, progressing from pretest levels (1.77 ± 0.85) to posttest levels (2.39 ± 0.84). This enhancement moved the criteria from moderately critical to critical. Similarly, the analysis and inference indicators exhibited a significant positive shift, transitioning from less critical to critical, as evidenced by a positive n-gain. However, in the evaluation aspect, while an improvement was observed, critical thinking skills lingered at the critical level (2.39 ± 0.86). In summary, the intervention demonstrated a positive impact on enhancing critical thinking skills in the domains of interpretation, analysis, and inference. Nevertheless, it is evident that further attention is warranted to fortify evaluative skills.

Moving forward, Table 3 and Figure 2 provide the results of the descriptive analysis conducted on the control class, focusing on the parameters of average critical thinking score and n-gain for each indicator. This comparative analysis offers insights into the critical thinking skills of the control group in contrast to the experimental group. The findings contribute to a comprehensive understanding of the intervention's effectiveness by elucidating the nuances of critical thinking development in both experimental and control settings.

Table 3. The results of descriptive analysis of control class critical thinking skills based on the average indicator score and n-gain parameters.

Indicator	N	Pretest			Posttest			n-gain	Criteria
		Min	Max	Mean (SD)	Min	Max	Mean (SD)		
Interpretation	35	0.00	3.00	1.48(±0.85) (enough critical)	1.00	2.50	1.86(±0.45) (enough critical)	0.48	Moderate

Indicator	N	Pretest			Posttest			n-gain	Criteria
		Min	Max	Mean (SD)	Min	Max	Mean (SD)		
Analysis	35	0.00	2.00	0.63(±0.55) (less critical)	0.00	2.50	1.62(±0.46) (enough critical)	0.54	Moderate
Inference	35	0.00	2.00	1.07(±0.57) (less critical)	0.50	2.00	1.42(±0.68) (enough critical)	0.30	Moderate
Evaluate	35	0.00	1.50	0.65(±0.58) (not critical)	0.00	2.00	1.14(±0.58) (enough critical)	0.22	Low

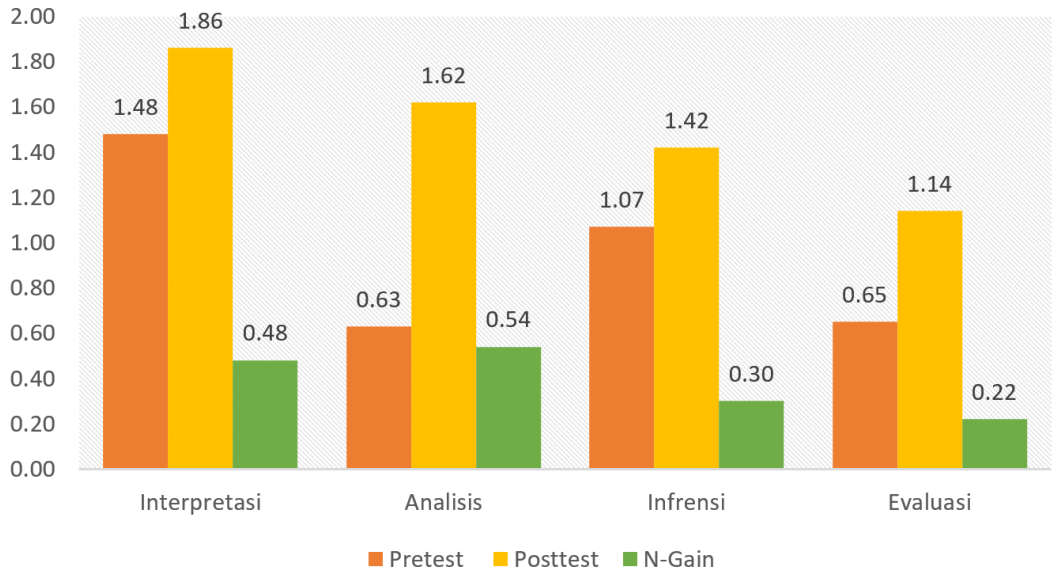

Figure 2. Illustrating the outcomes derived from a descriptive analysis of critical thinking skills in the control class, utilizing average indicator scores and n-gain parameters.

Table 3 and Figure 2 present the findings from the descriptive analysis of critical thinking skills in the control class, focusing on average indicator scores and n-gain parameters. In terms of pretest interpretation, scores ranged from 0.00 to 3.00, while posttest scores varied from 1.00 to 2.50. The n-gain for interpretation demonstrated a moderate increase of 0.48. The pretest analysis yielded scores between 0.00 and 2.00, with the posttest showing a range of 0.00 to 2.50. The n-gain for analysis was 0.54, indicating moderate improvement. In the inference category, pretest scores ranged from 0.00 to 2.00, and posttest scores ranged from 0.50 to 2.00, resulting in an n-gain of 0.30, signifying a moderate increase. Evaluation scores for the pretest were between 0.00 and 1.50, while posttest scores ranged from 0.00 to 2.00, with an n-gain of 0.22, indicating a low level of improvement. The critical thinking skills of the control class exhibited improvement, particularly in interpretation and analysis. However, the evaluation aspect showed a relatively lower increase. Additionally, Table 4 presents the results of descriptive analysis, focusing on the average total score of classical critical thinking in both the experimental and control classes.

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

Class	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 displays the findings from the descriptive analysis, focusing on the average total score of classical critical thinking in both the experimental and control groups. The experimental group, comprising 31 students, exhibited a discernible shift in scores between the pretest and posttest, resulting in an n-gain value of 0.70, indicative of a moderate increase. The average total critical thinking score for the experimental group stood at 18.68, ranging from 15.00 to 23.00.

In contrast, the control group, comprising 35 students, demonstrated a lower n-gain of 0.27, classifying it as a low gain. The average total critical thinking score in the control group was 12.11, with a score range of 10.00 to 15.00. Using predefined criteria, the improvement in critical thinking within the experimental group can be considered moderate, whereas the control group experienced a comparatively lower increase, specifically categorized as low. Subsequently, statistical tests were conducted to examine the differences in students' critical thinking skill scores between the two classes. Prior to this analysis, normality and homogeneity tests were performed, and the results are detailed in Table 5.

Table 5. Normality and homogeneity test results

Class	Score	N	Normality			Homogeneity	
			Mean	SD	Sig.	Levine test	Sig.
Experimental	Pre-test	31	6.65	2.027	0.217	8.196	0.06
	Post-test	31	18.68				
Control	Pre-test	35	7.66	1.272	0.311		
	Post-test	35	12.11				

The test results for both classes showed that the experimental and control classes had a normal and homogeneous distribution ($p > 0.05$). Based on these results, a paired sample t-test was carried out ($p < 0.05$), the results are presented in Table 6.

Table 6. Results of the paired sample t-test ($p < 0.05$)

Pair	Score	N	Mean	SD	t	Df	p
Pair 1	Pretest, exp.	31	-12.129	2.125	-31.778	30	0.000
	Posttest, exp.	31					
Pair 2	Pretest, cont.	35	-4.343	1.679	-15.299	33	0.000
	Posttest, cont.	35					

Table 6 displays the outcomes of paired sample t-tests for two sets of experimental groups (Pair 1) and control groups (Pair 2) at a significance level of $p < 0.05$. Within Pair 1, a noteworthy disparity emerged between the pretest and posttest scores of the experimental group, registering a mean pretest score of -12.129 and posttest score of -31.778, with a p-value of 0.000. This underscores a substantial enhancement in the performance of the experimental group following the intervention. Meanwhile, in Pair 2, the test outcomes demonstrated a significant distinction in the pretest and posttest scores of the control group, exhibiting a mean pretest score of -4.343 and posttest score of -15.299, with a p-value of 0.000. These findings indicate that the control group also underwent substantial changes post-intervention, albeit with a magnitude lower than that observed in the experimental group. In light of these results, the acceptance of Ha is warranted, confirming a significant effect of the ethnoscience integrated problem-based learning model on the enhancement of students' critical thinking skills. Furthermore, these outcomes underscore the inadequacy of traditional (expository) teaching methods in fostering improvements in students' critical thinking abilities.

Current research has elucidated the profound impact of the ethnoscience integrated problem-based learning (PBL) model in enhancing students' critical thinking skills. PBL, characterized by its student-centric methodology that fosters active participation, collaboration, and problem-solving, has been lauded as an effective educational approach (Aliyu et al., 2023). The infusion of ethnoscience, which integrates cultural knowledge into the curriculum, adds a layer of contextual relevance to the learning process (Verawati, Harjono, et al., 2022). The amalgamation of these two pedagogical approaches aspires to create a comprehensive learning milieu, not only nurturing subject-specific knowledge but also propelling the development of critical thinking skills among students.

The research findings underscore a noteworthy positive impact on students' critical thinking abilities. The outcomes of the paired samples t-test, as depicted in Table 6, illustrate a substantial enhancement in the experimental group. The mean difference between pretest and posttest scores indicates a remarkable improvement in critical thinking skills, aligning with prior research that

underscores the efficacy of PBL in cultivating higher-order thinking, particularly critical thinking (Suhirman & Prayogi, 2023; Suhirman & Ghazali, 2022). PBL, through its emphasis on exploration in the learning process, has been shown to elevate thinking skills and exert a broad influence on various learning outcomes, as corroborated by existing research (Biazus & Mahtari, 2022; Bilad, Anwar, et al., 2022; Fitriani et al., 2022; Prayogi et al., 2023; Verawati, Handriani, et al., 2022). The integration of ethnoscience augments this impact by providing a cultural context, urging students to employ critical thinking across diverse perspectives (Prayogi et al., 2022).

An aspect deserving attention is the contextual learning experience facilitated by the integration of ethnoscience. This research aligns with the notion that learning is most effective when situated in a familiar context for students. The inclusion of ethnoscience in the PBL model enhances cultural relevance, enabling students to link theoretical concepts with real-world applications rooted in their cultural background. This approach not only deepens comprehension but also contributes significantly to the development of critical thinking skills. Comparative analysis with earlier research reinforces the effectiveness of PBL integrated with the ethnoscience model, with similar interventions demonstrating positive impacts on critical thinking skills in diverse educational contexts (Prayogi et al., 2022; Verawati, Harjono, et al., 2022). This study adds to the expanding body of evidence supporting the versatility and efficacy of such integrated approaches, underscoring the necessity for educational strategies addressing both subject-specific content and the broader skills essential for success in diverse academic and professional environments.

CONCLUSION

In conclusion, this study illuminates the substantial positive influence of the ethnoscience integrated problem-based learning model on students' critical thinking skills. The findings, supported by statistical analyses, reveal a significant improvement in critical thinking abilities among students in the experimental class compared to those in the control class. The integrated approach, combining problem-based learning and ethnoscience, not only addresses the limitations of traditional expository teaching but also provides a more meaningful and culturally relevant educational experience. Furthermore, the research underscores the ongoing deficiency in students' critical thinking proficiency within the current educational paradigm, particularly in the context of science education. The integration of local wisdom values through ethnoscience emerges as a promising avenue to bridge this gap, offering a contextually rich learning environment that fosters deeper understanding and application of scientific concepts. The study advocates for a shift towards innovative pedagogical models that actively engage students in analyzing and solving real-world problems, aligning with the principles of problem-based learning.

In summary, the significance of this research extends beyond the specific context of ethnoscience integrated problem-based learning, emphasizing the broader importance of nurturing critical thinking skills in the 21st-century educational landscape. As education continues to evolve, it is imperative to explore and embrace effective pedagogical interventions that empower students with the cognitive skills necessary for success in an increasingly complex and interconnected world.

LIMITATIONS AND FUTURE IMPLICATIONS

Despite the valuable insights gained from this study, it is essential to acknowledge its limitations. Firstly, the research was conducted in a specific secondary school in Mataram City, Indonesia, which may limit the generalizability of the findings to other educational settings or diverse cultural contexts. The homogeneity of the sample in terms of geographical and socio-cultural aspects may affect the external validity of the study. Additionally, the quasi-experimental design, while providing valuable insights, falls short of establishing causal relationships definitively. Other confounding variables not accounted for in the study could potentially influence the observed differences in critical thinking skills between the experimental and control groups.

Looking ahead, future research endeavors should strive to address these limitations and explore the broader implications of integrating ethnoscience into problem-based learning models. A more extensive and diverse sample from various geographic locations and cultural backgrounds could enhance the external validity and generalizability of the findings. Furthermore, longitudinal

studies could provide a deeper understanding of the sustained impact of the ethnoscience integrated problem-based learning model on students' critical thinking skills over an extended period. Additionally, exploring the perspectives and experiences of educators and students in implementing this pedagogical approach would contribute valuable qualitative insights. As education continues to evolve, research in this domain can inform evidence-based practices that promote not only subject-specific knowledge but also the development of essential cognitive skills for students worldwide.

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REFERENCES

Agustin, N., Sudarmin, S., Sumarti, S. S., & Addiani, A. K. (2018). Desain Instrumen Tes Bermuatan Etnosains Untuk Mengukur Kemampuan Berpikir Kritis Siswa. *Jurnal Inovasi Pendidikan Kimia*, *12*(2), Article 2. https://doi.org/10.15294/jipk.v12i2.15475

Aliyu, H., Ebikabowei, M., & Kola, A. J. (2023). Problem-Based Learning in Remote Learning Scenario Utilizing Climate Change Virtual Reality Video in Mobile Application to Train Critical Thinking. *International Journal of Essential Competencies in Education*, *2*(2), 144–159. https://doi.org/10.36312/ijece.v2i2.1612

Amri, S. (2015). *Implemntasi Pembelajaran Aktif dalam Kurikulum 2013*.

Biazus, M. de O., & Mahtari, S. (2022). The Impact of Project-Based Learning (PjBL) Model on Secondary Students' Creative Thinking Skills. *International Journal of Essential Competencies in Education*, *1*(1), 38–48. https://doi.org/10.36312/ijece.v1i1.752

Bilad, M. R., Anwar, K., & Hayati, S. (2022). Nurturing Prospective STEM Teachers' Critical Thinking Skill through Virtual Simulation-Assisted Remote Inquiry in Fourier Transform Courses. *International Journal of Essential Competencies in Education*, *1*(1), Article 1. https://doi.org/10.36312/ijece.v1i1.728

Bilad, M. R., Doyan, A., & Susilawati, S. (2022). Analyzing STEM Students' Critical Thinking Performance: Literacy Study on the Polymer Film Fabrication Process Irradiated with Gamma Rays. *International Journal of Essential Competencies in Education*, *1*(2), Article 2. https://doi.org/10.36312/ijece.v1i2.782

Defiyanti, & Sumarni, W. (2020). Analisis Kemampuan Berpikir Kritis Setelah Penerapan Problem Based Learning Berbantuan Lembar Kerja Peserta Didik Bermuatan Etnosains. *Phenomenon : Jurnal Pendidikan MIPA*, *9*(2), Article 2. https://doi.org/10.21580/phen.2019.9.2.4200

Ekayanti, B. H., Prayogi, S., & Gummah, S. (2022). Efforts to Drill the Critical Thinking Skills on Momentum and Impulse Phenomena Using Discovery Learning Model. *International Journal of Essential Competencies in Education*, *1*(2), Article 2. https://doi.org/10.36312/ijece.v1i2.1250

Falah, C. M. N., & windyariani, S. (2018, March 2). *Peningkatan Kemampuan Berpikir Kritis Peserta Didik Melalui Model Pembelajaran Search, Solve, Create, and Share (SSCS) Berbasis Etnosains*. https://garuda.kemdikbud.go.id/documents/detail/701353

Fitriani, H., Samsuri, T., Rachmadiarti, F., Raharjo, R., & Mantlana, C. D. (2022). Development of Evaluative-Process Learning Tools Integrated with Conceptual-Problem-Based Learning Models: Study of Its Validity and Effectiveness to Train Critical Thinking. *International Journal of Essential Competencies in Education*, *1*(1), Article 1. https://doi.org/10.36312/ijece.v1i1.736

Gultom, M., & Adam, D. H. (2018). Pengaruh Pendekatan Pembelajaran Problem Based Learning terhadap Kemampuan Berpikir Kritis Siswa di MTS Negeri Rantauprapat. *Jurnal Pembelajaran dan Biologi Nukleus*, *4*(2), Article 2. https://doi.org/10.36987/jpbn.v4i2.1595

Hake, R., R. (1999). *Analyzing change/gain scores*. Indiana University: Woodland Hills, CA - USA.

Haryanti, Y. D. (2017). Model Problem Based Learning Membangun Kemampuan Berpikir Kritis Siswa Sekolah Dasar. *Jurnal Cakrawala Pendas*, *3*(2), Article 2. https://doi.org/10.31949/jcp.v3i2.596

Nofziarni, A., Hadiyanto, H., Fitria, Y., & Bentri, A. (2019). Pengaruh Penggunaan Model Problem Based Learning (PBL) Terhadap Hasil Belajar Siswa di Sekolah Dasar. *Jurnal Basicedu*, *3*(4), Article 4. https://doi.org/10.31004/basicedu.v3i4.244

Prayogi, S., Ahzan, S., Indriaturrahmi, I., & Rokhmat, J. (2022). Opportunities to Stimulate the Critical Thinking Performance of Preservice Science Teachers Through the Ethno-Inquiry Model in an E Learning Platform. *International Journal of Learning, Teaching and Educational Research*, *21*(9), Article 9. https://www.ijlter.org/index.php/ijlter/article/view/5818

Prayogi, S., Ardi, R. F. P., Yazidi, R. E., Tseng, K.-C., & Mustofa, H. A. (2023). The Analysis of Students' Design Thinking in Inquiry-Based Learning in Routine University Science Courses. *International Journal of Essential Competencies in Education*, *2*(1), Article 1. https://doi.org/10.36312/ijece.v2i1.1338

Prayogi, S., Yuanita, L., & Wasis. (2018). *Critical Inquiry Based Learning: A model of Learning to Promote Critical Thinking Among of Prospective Teacher of Physic.*

Salvetti, F., Rijal, K., Owusu-Darko, I., & Prayogi, S. (2023). Surmounting Obstacles in STEM Education: An In-depth Analysis of Literature Paving the Way for Proficient Pedagogy in STEM Learning. *International Journal of Essential Competencies in Education*, *2*(2), 177–196. https://doi.org/10.36312/ijece.v2i2.1614

Sari, R. N., Ahda, Y., & Yanti, F. (2019). Effectiveness of Guided Inquiry Learning Model and Problem Based Learning Learning Model on Thematic Integrated Learning Competency. *International Journal of Educational Dynamics*, *1*(2), Article 2. https://doi.org/10.24036/ijeds.v1i2.188

Suhirman, & Prayogi, S. (2023). Problem-based learning utilizing assistive virtual simulation in mobile application to improve students' critical thinking skills. *International Journal of Education and Practice*, *11*(3), 351–364. https://doi.org/10.18488/61.v11i3.3380

Suhirman, S., & Ghazali, I. (2022). Exploring Students' Critical Thinking and Curiosity: A Study on Problem-Based Learning with Character Development and Naturalist Intelligence. *International Journal of Essential Competencies in Education*, *1*(2), 95–107. https://doi.org/10.36312/ijece.v1i2.1317

Temuningsih, Peniati, & Marianti. (2017). *Pengaruh Penerapan Model Problem Based Learning Berpendekatan Etnosains pada Materi Sistem Reproduksi terhadap Kemampuan Berpikir Kritis Siswa*.

Verawati, N. N. S. P., Handriani, L. S., & Prahani, B. K. (2022). The Experimental Experience of Motion Kinematics in Biology Class Using PhET Virtual Simulation and Its Impact on Learning Outcomes. *International Journal of Essential Competencies in Education*, *1*(1), Article 1. https://doi.org/10.36312/ijece.v1i1.729

Verawati, N. N. S. P., Harjono, A., Wahyudi, W., & Gummah, S. (2022). Inquiry-Creative Learning Integrated with Ethnoscience: Efforts to Encourage Prospective Science Teachers' Critical Thinking in Indonesia. *International Journal of Learning, Teaching and Educational Research*, *21*(9), Article 9. https://www.ijlter.org/index.php/ijlter/article/view/5890