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Enhancing Pre-Service Teachers' Creativity through Ethno-STEM Project-Based Learning in an Elementary Science Teaching Course

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Abstract: This study investigated the extent to which the implementation of an Ethno-STEM Project-Based Learning model contributes to the development of pre-service teachers' creative thinking skills in designing elementary science instruction. A quantitative pre-experimental approach employing a one-group pretest–posttest design was conducted in three classes involving pre-service teachers enrolled in an elementary science teaching course. Data were obtained using validated instruments designed to assess creative thinking skills in developing science learning designs for elementary education. The analysis revealed a notable increase in students' creative thinking performance after participating in the learning activities. The average N-gain score reached 62.15%, indicating a moderate level of improvement. These results demonstrate that integrating local cultural contexts into STEM-oriented project-based learning provides meaningful opportunities for pre-service teachers to develop creative, contextually relevant instructional designs. The findings highlight the potential of the Ethno-STEM Project-Based Learning model as an alternative approach for strengthening creative instructional design skills in elementary science teacher education.

Keywords: Pre-service Teacher, Creativity, Ethno-STEM, Project Based Learning, Elementary Science Teaching Course

***Abstrak**: Penelitian ini mengkaji sejauh mana penerapan model Ethno-STEM Project-Based Learning berkontribusi terhadap pengembangan keterampilan berpikir kreatif calon guru dalam merancang pembelajaran IPA di sekolah dasar. Penelitian menggunakan pendekatan kuantitatif dengan desain pra-eksperimen berupa one-group pretest–posttest yang dilaksanakan pada tiga kelas yang terdiri atas mahasiswa calon guru yang menempuh mata kuliah pembelajaran IPA SD. Data dikumpulkan menggunakan instrumen yang telah divalidasi untuk mengukur keterampilan berpikir kreatif dalam mengembangkan desain pembelajaran IPA pada jenjang sekolah dasar. Hasil analisis menunjukkan adanya peningkatan kemampuan berpikir kreatif mahasiswa setelah mengikuti proses pembelajaran. Rata-rata skor N-gain yang diperoleh sebesar 62,15%, yang termasuk dalam kategori peningkatan sedang. Temuan ini menunjukkan bahwa integrasi konteks budaya lokal ke dalam pembelajaran berbasis proyek berorientasi STEM memberikan peluang yang bermakna bagi calon guru untuk mengembangkan desain pembelajaran yang kreatif dan kontekstual. Dengan demikian, model Ethno-STEM Project-Based Learning memiliki potensi sebagai salah satu alternatif pendekatan dalam pendidikan calon guru sekolah dasar untuk memperkuat keterampilan merancang pembelajaran IPA yang kreatif.*

***Kata Kunci:** Calon Guru, Kreativitas, Ethno-STEM, Project Based Learning, Matakuliah Pembelajaran IPA SD*

INTRODUCTION

Science education at the elementary school level plays a crucial role in establishing students' foundational understanding of natural phenomena and fostering higher-order thinking skills. However, science instruction in primary education is still frequently dominated by conventional approaches that are largely theoretical, lack contextual relevance, and fail to engage learners

(Nurmalasari et al., 2024) actively. Such conditions often lead to low motivation to learn and limited student participation in the learning process.

For pre-service teachers, the ability to design engaging, relevant, and context-based science instruction remains a significant challenge. They are expected to demonstrate creativity in developing meaningful learning experiences. Creativity, as defined by J. P. Guilford (1967), encompasses divergent thinking, flexibility, originality, and elaboration, skills that are essential for educators in the 21st century. These competencies not only contribute to effective science teaching but also facilitate meaningful learning experiences for students (Naimah, 2022).

In response to these challenges, the Ethno-STEM approach, which integrates elements of science, technology, engineering, and mathematics (STEM) with local cultural wisdom, offers a promising alternative for contextualizing science learning (Primadianningsih et al., 2023). Ethno-STEM enhances the relevance of learning by connecting scientific concepts to students' sociocultural environments, thereby increasing engagement and supporting the development of critical thinking (Hikmah et al., 2023) and creativity (Izzah & Wardani, 2023). This approach becomes even more effective when combined with Project-Based Learning (PjBL), which emphasizes authentic, inquiry-driven learning experiences.

Project-Based Learning enables learners to develop collaboration, problem-solving, and creative skills through the exploration of real-world problems and the production of authentic outputs (Arsinah & Kadir, 2024). In teacher education, integrating Ethno-STEM and PjBL provides pre-service teachers with opportunities to design culturally relevant instructional modules and learning media aligned with STEM principles. For instance, pre-service teachers may develop simple experiments using traditional technologies, explain scientific concepts through local practices, or create instructional media utilizing locally available materials.

Despite its considerable potential, the implementation of Ethno-STEM-based PjBL in higher education, particularly in elementary science teaching courses, remains limited. Empirical studies examining its effectiveness in enhancing pre-service teachers' creativity are still scarce. This gap is noteworthy, considering that creativity is a critical competency required for future teachers to design innovative and culturally responsive instruction. To address this gap, this study investigates the effectiveness of the Ethno-STEM Project-Based Learning model in improving pre-service teachers' creative thinking skills in designing elementary science instruction. The study employs a quasi-experimental method with a pretest–posttest control group design. The implementation of the Ethno-STEM PjBL model involves several key stages, including the identification of local culture-based problems, STEM-oriented project planning, development of innovative products, testing and evaluation, and reflective learning.

The problem-solving approach in this study is grounded in the application of Ethno-STEM PjBL to address pre-service teachers' limited creativity in designing engaging, contextually relevant science instruction. Through authentic project-based activities, students are encouraged to connect scientific concepts with local phenomena, thereby enhancing both conceptual understanding and creative capacity. The lecturer acts as a facilitator, guiding the learning process and ensuring that project development remains aligned with learning objectives. This approach promotes active student engagement (Sumarni & Kadarwati, 2020) and supports the development of creativity through culturally contextualized instructional design (Babalola & Keku, 2024). From theoretical and practical perspectives, this study advances innovative learning models by integrating Ethno-STEM principles into a project-based framework. Ethno-STEM offers distinct advantages by linking scientific knowledge to local cultural values (Martawijaya et al., 2023), thereby increasing the relevance of learning and encouraging active student participation (Islami et al., 2024), while ethnoscience bridges modern scientific knowledge and indigenous practices (Ismail et al., 2024). Furthermore, PjBL has been widely recognized as an effective approach in higher education (Guo et al., 2020), particularly in enhancing creativity through authentic project development (Chen et al., 2022) and promoting critical thinking, collaboration, and problem-solving skills (Ramadhan & Hindun, 2023).

This study also emphasizes key dimensions of creativity fluency, flexibility, originality, and elaboration as essential indicators in evaluating creative thinking (Guildford, 1967). Therefore, the novelty of this research lies in the comprehensive integration of Ethno-STEM and Project-Based Learning to support the development of creative instructional design among pre-service teachers. Specifically, this study aims to determine the extent to which implementing the Ethno-STEM Project-Based Learning model improves pre-service teachers' creative thinking skills for designing elementary science instruction. By focusing on measurable improvements in creativity, this research seeks to provide empirical evidence of the model's effectiveness, thereby contributing to the development of innovative and culturally responsive science teaching practices in teacher education.

METHOD

This study aimed to examine the practicality and effectiveness of the Ethno-STEM Project-Based Learning (PjBL) model in enhancing the creativity of pre-service elementary school teachers. The research was conducted in a structured sequence: instrument development, implementation, data collection, analysis, and reporting. The initial stage involved developing research instruments and learning tools aligned with the Ethno-STEM PjBL model. The instruments were designed to measure three key aspects: the implementation of the learning process, the model's practicality, and its effectiveness in improving pre-service teachers' creativity. The instruments included (1) observation sheets to assess the implementation of learning activities, (2) questionnaires to capture responses from lecturers and students, and (3) a creativity test. The creativity test was constructed as essay questions covering key dimensions of creativity: fluency, flexibility, originality, and elaboration.

The implementation stage involved applying the Ethno-STEM PjBL model in an elementary science teaching course. During this stage, pre-service teachers engaged in project-based learning activities that integrated STEM concepts with local cultural contexts. The lecturer acted as a facilitator, guiding students throughout the learning process. A creativity test was administered before and after implementation to evaluate the model's effectiveness. The subjects of this study were pre-service teachers enrolled in the Elementary School Teacher Education Program (PGSD) at the Faculty of Teacher Training and Education, Universitas Mataram. The independent variable in this study was the Ethno-STEM PjBL model, while the dependent variable was pre-service teachers' creativity in designing elementary science instruction.

The subjects of this study were 90 fourth-semester pre-service teachers enrolled in the Elementary School Teacher Education Program (PGSD) at the Faculty of Teacher Training and Education, Universitas Mataram, Indonesia. The participants were drawn from three classes, each with approximately 30 students. They were enrolled in the Elementary Science Teaching course during the even semester of the 2024/2025 academic year. All participants received the same learning intervention based on the Ethno-STEM Project-Based Learning (PjBL) model. The independent variable in this study was the Ethno-STEM PjBL model, while the dependent variable was pre-service teachers' creativity in designing elementary science instruction.

Data collected in this study included both qualitative and quantitative data. Qualitative data, obtained from observations and open responses, were analyzed descriptively to identify patterns and tendencies during the learning process. Quantitative data, derived from creativity test scores and questionnaire responses, were analyzed using statistical techniques. To assess improvement in creativity, the normalized gain (N-gain) score was calculated using the formula proposed by Hake (1999).

$$\text{N - gain} = \frac{S_{post} - S_{pre}}{S_{max} - S_{pre}} \text{ x } 100\%$$

The N-gain values were categorized into three levels: high ($g > 70$), moderate ($30 \leq g \leq 70$), and low ($g < 30$).

Finally, the results of the analysis were interpreted and discussed in relation to relevant literature. The findings were then reported and prepared for publication to contribute to the development of innovative learning models in teacher education.

RESULT AND DISCUSSION

The findings of this study indicate that implementing the Ethno-STEM Project-Based Learning (PjBL) model resulted in a moderate improvement in pre-service teachers' creative thinking skills. This improvement, as measured through N-gain analysis, demonstrates that the model is effective in fostering creativity, particularly in the context of designing elementary science instruction. These results are consistent with previous studies highlighting the effectiveness of integrating Ethno-STEM with project-based learning in enhancing higher-order thinking skills.

A study by the Effectiveness of Ethno-STEM Project-Based Learning Model reported that the model significantly improves creativity, critical thinking, and conceptual understanding among prospective teachers. The study found that creativity improvements were observed across all key indicators, including fluency, flexibility, originality, and elaboration, which align closely with the dimensions assessed in the present study.

The improvement in creativity observed in this study can be explained by the contextual nature of Ethno-STEM learning. By integrating local cultural knowledge into STEM-based activities, students are encouraged to connect abstract scientific concepts with real-life experiences. This finding is supported by research emphasizing that Ethno-STEM enhances the relevance of learning and student engagement, ultimately promoting creative and critical thinking skills. Furthermore, incorporating local wisdom into science education has been shown to strengthen students' ability to generate meaningful and innovative ideas, as cultural contexts provide rich sources of inspiration for problem-solving.

In addition, the project-based learning component plays a crucial role in fostering creativity. PjBL engages students in authentic, inquiry-driven tasks that require them to design, develop, and evaluate products. A systematic review of project-based learning studies indicates that PjBL significantly enhances creativity, critical thinking, collaboration, and scientific literacy. Through project activities, students are not only exposed to real-world problems but also required to produce original, well-developed solutions, which directly support the development of the originality and elaboration aspects of creativity.

The collaborative nature of PjBL also contributes to the observed improvement. Student interaction allows the exchange of diverse perspectives, fostering flexibility in thinking. This aligns with findings that creativity is enhanced when learners engage in collaborative and socially interactive learning environments. Moreover, Ethno-STEM-integrated PjBL has been identified as an innovative instructional approach that develops essential 21st-century skills, including creative thinking, communication, and collaboration.

Despite the positive outcomes, the moderate N-gain category suggests that the improvement in creativity has not yet reached an optimal level. This may be influenced by several factors, such as limited implementation time, students' initial unfamiliarity with Ethno-STEM approaches, or the need for stronger scaffolding during project development. Similar findings have been reported in previous studies, in which the effectiveness of PjBL depends on factors such as instructional design quality, facilitation, and implementation duration.

Overall, the findings of this study reinforce the theoretical perspective that integrating cultural context (Ethno-STEM) with active learning strategies (PjBL) creates a powerful learning environment for fostering creativity. This approach not only enhances pre-service teachers' creative thinking skills but also prepares them to design science instruction that is meaningful, contextual, and culturally responsive. Therefore, the Ethno-STEM PjBL model can be considered a promising pedagogical strategy in teacher education, particularly in improving creative instructional design competencies for elementary science learning.

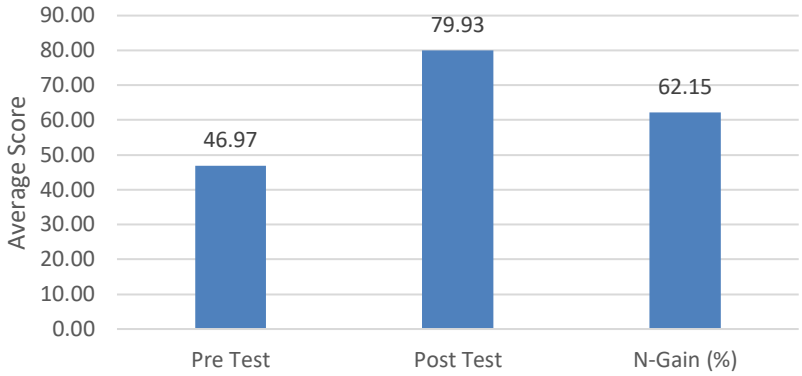

Figure 1. Comparison of Pre-Test and Post-Test Creativity Scores

Figure 1 indicates a substantial improvement in pre-service teachers' creative thinking skills following the implementation of the Ethno-STEM Project-Based Learning (PjBL) model. The average pre-test score of 46.97 indicates a relatively low baseline of creativity, suggesting that students initially had difficulty generating diverse, original, and well-elaborated ideas in the context of elementary science instruction. After the intervention, the average post-test score increased to 79.15, indicating that students achieved a good level of creative thinking. This improvement demonstrates that the Ethno-STEM PjBL model effectively fosters creativity through structured, contextual, and project-oriented learning experiences.

The observed improvement can be explained by the integration of cultural context within STEM learning. Ethno-STEM provides opportunities for students to connect scientific concepts with local knowledge and real-life experiences, thereby enhancing engagement and idea generation. Recent studies have highlighted that culturally responsive STEM learning environments significantly improve students' creativity and problem-solving skills by making learning more meaningful and relevant (e.g., STEM education integration in local contexts) (Li et al., 2022). In addition, ethnoscience-based learning has been shown to strengthen students' ability to generate innovative ideas by linking modern science with indigenous knowledge systems (Aikenhead, 2020).

The N-gain value of 62.15% indicates a moderate level of improvement, suggesting that the Ethno-STEM PjBL model is effective but still has room for optimization. This finding aligns with recent research on Project-Based Learning, which confirms that PjBL significantly enhances creativity through authentic and inquiry-driven learning tasks (Chen et al., 2022). Through project-based activities, students are required to design instructional modules and learning media, which fosters originality and elaboration. Moreover, PjBL promotes active engagement, collaboration, and problem-solving, all of which are essential components of creative thinking in the 21st century (Miller et al., 2021).

The moderate category of improvement may also be influenced by the complexity of developing higher-order creativity skills. Indicators such as originality and elaboration require deeper cognitive processing and longer practice. Recent studies suggest that extended implementation time, continuous feedback, and structured scaffolding are necessary to maximize the impact of PjBL on the development of creativity (Tijani & Adeduyigbe, 2026). In this study, although students demonstrated improvement, further enhancement could be achieved by providing more complex project challenges and integrating iterative design processes.

Furthermore, the findings confirm that Ethno-STEM PjBL not only enhances creativity but also fosters broader competencies, such as environmental awareness, cultural appreciation, and entrepreneurial thinking. Integrating local wisdom into STEM learning has been identified as an effective strategy for developing sustainable, context-based educational models (Rahmawati et al., 2025). This is particularly relevant in teacher education, where pre-service teachers are expected to design learning experiences that are both innovative and culturally responsive.

In addition to the overall improvement, the analysis of creativity indicators (fluency, flexibility, originality, and elaboration) provides a more nuanced understanding of students'

development. As illustrated in Figure 2, certain dimensions such as fluency and flexibility tend to improve more rapidly, while originality and elaboration require more intensive instructional support. This finding is consistent with recent studies indicating that different dimensions of creativity develop at different rates depending on the learning environment and instructional design (Runco, 2014).

Overall, the results of this study confirm that the Ethno-STEM Project-Based Learning model is a promising approach for enhancing pre-service teachers' creative thinking skills in elementary science education. By combining cultural relevance with active, project-based learning, the model creates meaningful learning experiences that support both conceptual understanding and creative instructional design.

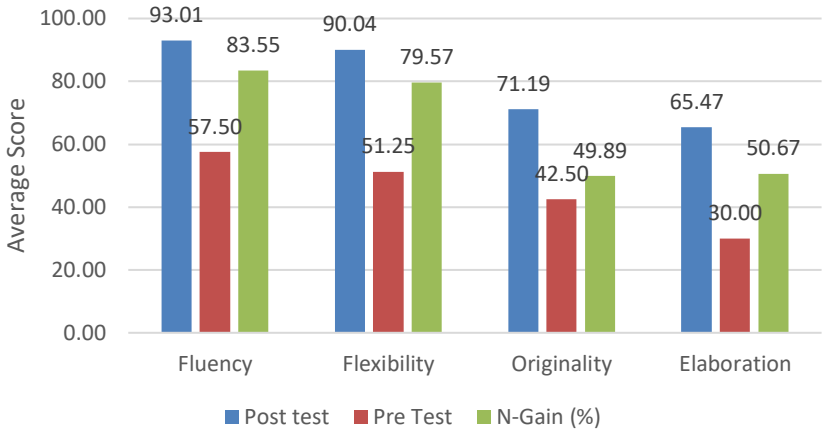

Figure 2. Comparison of Average Creativity Scores by Indicator

The analysis of creativity indicators in this study reveals that implementing the Ethno-STEM Project-Based Learning (PjBL) model led to improvements across all dimensions of creative thinking. However, the magnitude of improvement varies among indicators, reflecting differences in cognitive complexity and the nature of each creative skill.

In terms of fluency, the pre-test score of 57.50 increased significantly to 93.01 in the post-test, with an N-gain of 83.55%, categorized as high. This result indicates that students became more capable of generating multiple ideas and alternative solutions when responding to science-related problems. The substantial improvement in fluency can be attributed to the open-ended, exploratory nature of project-based learning, which encourages students to generate a wide range of ideas. This finding is consistent with research showing that project-based and inquiry-driven learning environments significantly enhance idea generation and creative productivity (e.g., the development of creative thinking in STEM contexts) (Henriksen et al., 2018). The iterative process involved in project work allows students to continuously refine and expand their ideas, thereby strengthening their fluency.

Similarly, the flexibility indicator showed a marked improvement, with scores increasing from 51.25 to 90.04 and an N-gain of 79.57% (high category). This suggests that students developed the ability to approach problems from multiple perspectives and employ diverse strategies in designing solutions. The integration of local cultural contexts into STEM learning plays a critical role in enhancing flexibility by exposing students to diverse ways of thinking and problem-solving. Previous studies have emphasized that culturally responsive STEM learning promotes adaptive thinking and cognitive flexibility by encouraging learners to reinterpret knowledge across different contexts (Buxton & Lee, 2023). Moreover, PjBL provides students with opportunities to experiment with multiple approaches, aligning with its core objective of fostering exploration and innovation in learning (Ummah et al., 2019).

In contrast, the improvement in originality was moderate, with scores increasing from 42.50 to 71.19 and an N-gain of 49.89%. Although students demonstrated progress, their ability

to produce truly novel and unique ideas remained limited. This result may be influenced by the novelty of the Ethno-STEM approach for students, as they may still be in the process of adapting to integrating cultural knowledge with scientific concepts. Research indicates that originality is one of the most complex dimensions of creativity, as it requires not only knowledge integration but also the ability to diverge from conventional thinking patterns (Runco, 2012). Therefore, sustained exposure to open-ended, less-structured learning environments is necessary to develop this aspect further.

A similar pattern was observed in the elaboration indicator, where the score increased from 30.00 to 65.47, with an N-gain of 50.67% (moderate category). This indicates that students began to improve their ability to expand, detail, and refine their ideas. However, the moderate improvement suggests that students still require additional support to develop more comprehensive, in-depth explanations. According to recent studies, elaboration skills are closely linked to metacognitive processes, such as reflection, evaluation, and iterative revision of ideas (Beghetto & van Geffen, 2024. Therefore, incorporating structured reflection activities and feedback mechanisms into project-based learning can significantly enhance students' ability to elaborate.

Overall, the findings confirm that the Ethno-STEM PjBL model is particularly effective in enhancing fluency and flexibility, which are foundational aspects of creative thinking. However, the relatively moderate improvement in originality and elaboration highlights the need for more targeted instructional strategies. Providing more complex and ill-structured problems, encouraging risk-taking in idea generation, and integrating reflective practices can help students move beyond conventional thinking and develop deeper creative competencies.

These results are in line with recent international studies demonstrating that while project-based and STEM-integrated learning environments effectively promote basic creative skills, advanced dimensions such as originality and elaboration require longer-term and more intensive interventions (Vincent-Lancrin, 2025). Therefore, the implementation of Ethno-STEM PjBL should be sustained and continuously refined to maximize its impact on all dimensions of creativity.

One of the key contributions of this study lies in the integration of Ethno-STEM, which situates scientific learning within local cultural contexts. This approach is grounded in the premise that knowledge is not only constructed cognitively but also socially and culturally. By embedding local wisdom into STEM learning, students are encouraged to connect abstract scientific concepts with real-life experiences, thereby enhancing both engagement and creativity. Research published highlights that culturally contextualized STEM learning significantly improves students' creative thinking by making learning more meaningful and relevant (Rahmawati et al., 2022). Similarly, Aikenhead (2020) emphasizes that integrating indigenous knowledge systems into science education enhances students' ability to generate innovative ideas and fosters deeper conceptual understanding.

The effectiveness of Ethno-STEM can also be explained through constructivist learning theory, which posits that learners actively construct knowledge through interaction with meaningful contexts. In this study, the integration of local cultural elements provided such contexts, enabling students to reinterpret scientific concepts through culturally familiar frameworks. This process stimulates divergent thinking, a key component of creativity, as students are exposed to multiple perspectives and encouraged to generate varied solutions. Furthermore, ethnoscience-based learning has been shown to significantly enhance creative thinking by bridging modern scientific knowledge with traditional practices. A study by Susilawati et al. (2021) found that ethnoscience-integrated STEM learning improves both creativity and critical thinking skills among prospective teachers.

The integration of Ethno-STEM also supports culturally responsive pedagogy, which has been widely recognized as essential in contemporary education. Ladson-Billings (2021) argues that culturally relevant teaching enhances student engagement and promotes higher-order thinking by connecting learning to students' lived experiences. This aligns with the findings of this study, where students demonstrated increased fluency and flexibility after engaging in culturally contextualized

projects. In addition to cultural integration, the project-based learning component plays a crucial role in enhancing creativity. PjBL is widely recognized as an effective pedagogical approach that promotes active learning, collaboration, and problem-solving. In this study, students were engaged in designing instructional modules and learning media based on Ethno-STEM principles, requiring them to apply their knowledge creatively and produce authentic outputs.

Other research shows that PjBL significantly improves students' creativity by encouraging exploration, experimentation, and iterative refinement of ideas (Chen et al., 2021). The success of PjBL in this study can be attributed to its emphasis on authentic learning. Students are not merely passive recipients of knowledge but active participants in constructing their understanding. This aligns with experiential learning theory, which emphasizes learning through experience and reflection. Through project-based activities, students were able to explore real-world problems, generate ideas, and develop innovative solutions. Another important aspect of PjBL is its collaborative nature. Collaboration plays a significant role in enhancing creativity, as it exposes students to diverse perspectives and encourages the exchange of ideas. Research by Hmelo-Silver (2025) indicates that collaborative learning environments significantly enhance creative problem-solving skills by promoting interaction and knowledge sharing.

Despite the overall positive results, the study reveals differential improvements across creativity indicators. Fluency and flexibility showed significant improvement, while originality and elaboration remained in the moderate category. This finding is consistent with existing literature, which suggests that different components of creativity develop at different rates. Fluency and flexibility are considered foundational components of creativity and are relatively easy to develop through exposure to open-ended, exploratory learning environments. The high N-gain values for these indicators in this study indicate that the Ethno-STEM PjBL model effectively supports idea generation and adaptive thinking.

Similarly, elaboration involves developing ideas in depth, which requires metacognitive skills such as reflection, evaluation, and revision. Beghetto & van Geffen (2024) emphasize that elaboration is closely linked to metacognition and requires structured support, such as feedback and reflective activities. The moderate improvement in originality and elaboration observed in this study suggests that students may require more time and support to develop these skills fully. This is consistent with research indicating that higher-order creativity skills require longer-term interventions and more complex learning environments. Furthermore, the findings of this study highlight the importance of scaffolding in maximizing the effectiveness of PjBL. Scaffolding refers to the support provided by instructors to help students achieve learning goals. Research shows that appropriate scaffolding significantly enhances students' creativity by guiding them through complex tasks and encouraging deeper thinking (Anazifa & Djukri, 2017).

In addition to cognitive development, the Ethno-STEM PjBL model contributes to broader competencies, such as environmental awareness, cultural appreciation, and entrepreneurial skills. This is particularly relevant in the context of 21st-century education, where students are expected to develop not only academic knowledge but also transferable skills. A study by OECD (2022) highlights that creativity and critical thinking are essential competencies for the future workforce and should be integrated into all levels of education.

The integration of Ethno-STEM also supports sustainable education by promoting the use of local resources and encouraging students to develop solutions that are relevant to their communities. This aligns with the principles of Education for Sustainable Development (ESD), which emphasizes integrating social, cultural, and environmental aspects into education. Moreover, the findings of this study contribute to the growing body of literature on innovative learning models in teacher education. The increasing interest in Ethno-STEM and PjBL reflects a shift towards more contextual and student-centered approaches in education. This shift is driven by the need to prepare students for the challenges of the 21st century, which require creativity, adaptability, and problem-solving skills.

In conclusion, this study confirms that the Ethno-STEM Project-Based Learning model is an effective approach for enhancing pre-service teachers' creative thinking skills. The model not only

improves students' ability to generate and develop ideas but also equips them with the skills needed to design meaningful, contextual, and culturally responsive science instruction. However, further efforts are needed to optimize the development of advanced creativity skills, particularly originality and elaboration, through extended implementation and enhanced instructional support.

Beyond the primary findings, this study highlights important pedagogical implications for designing learning environments that effectively foster creativity among pre-service teachers. The integration of Ethno-STEM and Project-Based Learning (PjBL) represents a shift from traditional, teacher-centered instruction toward a more holistic, learner-centered approach that emphasizes contextual understanding, collaboration, and innovation. This shift is particularly relevant in teacher education, where future educators must be equipped not only with content knowledge but also with the ability to design meaningful and engaging learning experiences.

One important implication of this study is the role of contextualization in enhancing cognitive engagement. When students engage with culturally relevant content, they are more likely to perceive learning as meaningful, which in turn increases motivation and participation. Research by Gay (2021) emphasizes that culturally responsive teaching improves student engagement and academic performance by connecting learning with students' cultural backgrounds.

This finding is consistent with the results of this study, in which students demonstrated significant improvements in fluency and flexibility after engaging in culturally contextualized projects. The use of local wisdom as a learning resource not only enriches content but also provides diverse perspectives that stimulate creative thinking. Another critical aspect is the role of authentic tasks in promoting creativity. In this study, students were required to design instructional modules and learning media based on Ethno-STEM principles. These tasks required them to apply theoretical knowledge in practical contexts, which aligns with research showing that authentic learning experiences enhance creativity by encouraging students to solve real-world problems (Herrington et al., 2025). Furthermore, the iterative nature of project-based learning plays a crucial role in the development of creativity. Students are given opportunities to refine their ideas through feedback and reflection, which enhances both originality and elaboration. This process is supported by research showing that iterative design significantly improves creative outcomes (Kolodner, 1993).

However, the moderate improvement in originality and elaboration suggests that additional instructional strategies are needed to develop these dimensions fully. One possible approach is to integrate reflective practices, which encourage students to evaluate and refine their ideas critically. Research shows that reflection enhances metacognitive skills and supports deeper learning (Silver et al, 2023). Another important factor influencing the development of creativity is time allocation. Creativity, particularly originality, requires prolonged exposure to open-ended learning environments. Short-term interventions may not be sufficient to achieve optimal results. This is supported by longitudinal studies showing that sustained implementation of innovative learning models leads to greater improvements in creativity. The integration of Ethno-STEM also has implications for sustainable education. By incorporating local wisdom into learning, students develop an appreciation for cultural heritage and environmental sustainability. This aligns with the principles of Education for Sustainable Development (ESD), which emphasizes the importance of integrating social, cultural, and environmental aspects into education.

Moreover, the findings contribute to the broader discourse on 21st-century skills, particularly creativity, critical thinking, collaboration, and communication. These skills are increasingly recognized as essential for success in the modern workforce. Overall, this study provides strong evidence that the Ethno-STEM PjBL model is an effective approach for enhancing creativity in teacher education. However, several limitations should be acknowledged. First, the study involved pre-service teachers from a single institution, which may limit the generalizability of the findings to other educational contexts. Second, the intervention was conducted within one semester and focused solely on creativity, without examining other potential outcomes such as critical thinking, collaboration, or long-term retention of learning. In addition, the use of a one-group pretest-posttest design without a control group limits the ability to attribute changes exclusively to the intervention. Therefore, to maximize its impact, future implementations should

consider extending the learning duration, providing more structured scaffolding, incorporating reflective practices, and designing more complex, open-ended projects. These strategies can help students develop higher-level creativity skills, particularly originality and elaboration.

CONCLUSION

The findings of this study indicate that implementing the Ethno-STEM Project-Based Learning model positively improves pre-service teachers' creative thinking skills in designing elementary science instruction. The moderate N-gain score indicates that integrating local cultural contexts into STEM-oriented project activities yields meaningful learning experiences that support the development of creative, contextualized instructional designs. These results highlight the potential of the Ethno-STEM Project-Based Learning model as an effective approach for strengthening creative instructional competencies in elementary science teacher education.

Future studies are recommended to employ more rigorous research designs, such as quasi-experimental or mixed-methods approaches, and to involve larger, more diverse samples to gain a deeper understanding of the model's effectiveness. In addition, further research may explore the influence of the Ethno-STEM Project-Based Learning model on other 21st-century competencies, including critical thinking, problem-solving, collaboration, and scientific literacy. The integration of diverse local cultural contexts from different regions is also recommended to broaden the model's applicability in teacher education programs.

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REFERENCES

Aikenhead, G. (2020). School science and mathematics storylines. *Canadian Journal of Science, Mathematics and Technology Education*, 20(4), 682-699. https://doi.org/10.1007/s42330-020-00115-5

Arsinah, A., & Kadir, M. (2024). Implementasi Project Based Learning (PJBL) dalam Menumbuhkan Kreativitas pada Pembelajaran Ilmu Pengetahuan Alam dan Sosial (IPAS). *Jurnal Tarbiyah dan Ilmu Keguruan Borneo*, 5(3), 161-173. https://doi.org/10.21093/jtikborneo.v5i3.9366

Babalola, E. O., & Keku, E. (2024). Ethno-STEM Integrated Project-Based Learning to Improve Students' Creative Thinking Skills. *International Journal of Ethnoscience and Technology in Education*, 1(2), 116-130. 10.33394/ijete.v1i2.11308

Beghetto, R. A., & van Geffen, B. (2024). *Creativity assessment in schools and classrooms*. In Handbook of Creativity Assessment (pp. 234-252). Edward Elgar Publishing.

Buxton, C. A., & Lee, O. (2023). *Multilingual learners in science education. In Handbook of research on science education* (pp. 291-324). Routledge.

Chen, S. Y., Lai, C. F., Lai, Y. H., & Su, Y. S. (2022). Effect of project-based learning on development of students' creative thinking. *The International Journal of Electrical Engineering & Education*, 59(3), 232-250. https://doi.org/10.1177/0020720919846

Gay, G. (2021). *Culturally responsive teaching: Ideas, actions, and effects*. In Handbook of urban education (pp. 212-233). Routledge.

Guilford, J. P. (1967). Creativity: Yesterday, today and tomorrow. *The Journal of Creative Behavior*, 1(1), 3-14. https://doi.org/10.1002/j.2162-6057.1967.tb00002.x

Guo, P., Saab, N., Post, L. S., & Admiraal, W. (2020). A review of project-based learning in higher education: Student outcomes and measures. *International journal of educational research*, 102, 101586. 10.1016/j.ijer.2020.101586

Hake, R. R. (1999). Analyzing change/gain score.[Online] Tersedia: http://www. physics. indiana. edu/nsdi. AnalyzingChange-Gain. Pdf

Hanif, S., Wijaya, A. F. C., & Winarno, N. (2019). Enhancing Students' Creativity through STEM Project-Based Learning. *Journal of science Learning*, 2(2), 50-57.

Herrington, J. C., Biedermann, T. A., & Swift, B. (2025). Emerging Paradigms in Human–AI Creativity: From Visualisation to Biofeedback in Adaptive Interfaces. In Human-Computer Creativity: Generative AI in Education, Art, and Healthcare (pp. 31-48). *Cham: Springer Nature Switzerland*. https://doi.org/10.1007/978-3-031-86551-0_2

Henriksen, D., Henderson, M., Creely, E., Ceretkova, S., Černochová, M., Sendova, E., ... & Tienken, C. H. (2018). Creativity and technology in education: An international perspective. *Technology, Knowledge and Learning*, 23(3), 409-424. https://doi.org/10.1007/s10758-018-9380-1

Hiqmah, N., Rienovita, E., Al-Latief, I. S., Sholehuddin, S., & Santosa, T. A. (2023). Effectiveness of Ethno-STEM Based Chimistry to Improve Students Critical Thinking Skills. *Jurnal Penelitian Pendidikan IPA*, 9(SpecialIssue), 72-79. 10.29303/jppipa.v9iSpecialIssue.6422

Hmelo-Silver, C. E., Zou, X., & Danish, J. (2025). Instruction Based on Collaborative Learning. *Handbook of Research on Learning and Instruction*, 358-380.

Islami, J. M. M., Ilmin, L., Afny, D. N., Supriyanto, A., & Habibi, M. M. (2024). SLR: Penerapan Pembelajaran Berbasis Komunitas Untuk Meningkatkan Kompetensi Peserta Didik di Era Disrupsi. *Jurnal Ilmiah Profesi Pendidikan*, 9(4), 2832-2848. 10.29303/jipp.v9i4.2775

Ismail, I. A., Weriza, J., Mawardi, M., Lufri, L., Usmeldi, U., Festiyed, F., & Handri, S. (2024). Tinjauan Sistematis Analisis Integrasi Etnosains dalam Pembelajaran IPA dan Dampaknya terhadap Kompetensi Era Modern dan Nilai-nilai Pancasila. *Jurnal Pendidikan dan Teknologi Indonesia*, 4(5), 207-219. https://doi.org/10.52436/1.jpti.478

Izzah, S. N., & Wardani, S. (2023). Analysis of Science Concept Mastery, Creative Thinking Skills, and Environmental Attitudes After Ethno-STEM Learning Implementation. *International Journal of Instruction*, 16(3). https://e-iji.net/ats/index.php/pub/article/view/107

Kolodner, J.L. (1994). Understanding creativity: A case-based approach. In: Wess, S., Althoff, KD., Richter, M.M. (eds) Topics in Case-Based Reasoning. EWCBR 1993. Lecture Notes in Computer Science, vol 837. Springer, Berlin, Heidelberg. https://doi.org/10.1007/3-540-58330-0_73

Ladson-Billings, G. (2021, July). Three decades of culturally relevant, responsive, & sustaining pedagogy: What lies ahead?. In The educational forum (Vol. 85, No. 4, pp. 351-354). Routledge. https://doi.org/10.1080/00131725.2021.1957632

Li, Y., Xiao, Y., Wang, K., Zhang, N., Pang, Y., Wang, R., ... & Star, J. R. (2022). A systematic review of high impact empirical studies in STEM education. *International Journal of STEM Education*, 9(1), 72. https://doi.org/10.1186/s40594-022-00389-1

Martawijaya, M. A., Rahmadhanningsih, S., Swandi, A., Hasyim, M., & Sujiono, E. H. (2023). The effect of applying the Ethno-STEM-Project-based learning model on students' higher-order thinking skill and misconception of physics topics related to Lake Tempe, Indonesia. *Jurnal Pendidikan IPA Indonesia*, 12(1), 1-13. https://doi.org/10.15294/jpii.v12i1.38703

Miller, E. C., Severance, S., & Krajcik, J. (2021). Motivating teaching, sustaining change in practice: Design principles for teacher learning in project-based learning contexts. *Journal of Science Teacher Education*, 32(7), 757-779. https://doi.org/10.1080/1046560X.2020.1864099

Mukaromah, L., Mustadi, A., & Nisa, A. (2022). Study of STEM based on local wisdom in hoening science process skills in the 21st century era. *Jurnal Penelitian Pendidikan IPA*, 8(3), 1171-1175. 10.29303/jppipa.v8i3.1445

Musa, M. M., & Kamal, R. (2024). Project-based Learning Model for strengthening Elementary students' creativity in Sciences. *Jurnal Kependidikan: Penelitian Inovasi Pembelajaran*, 29-42. https://doi.org/10.21831/jk.v8i1.71718

Naimah, K. (2022). Inovasi Pembelajaran IPA SD dengan Pemanfaatan Media KIT Alat Sederhana yang Berasal dari Lingkungan Sekitar Untuk Meningkatkan Kompetensi dan Kreativitas Siswa. *Formosa Journal of Science and Technology*, 1(2), 97-110. https://doi.org/10.55927/fjst.v1i2.693

Nurmalasari, N., Radiah, R., Rahmawati, R., & Darmaniar, D. (2024). Penerapan Pembelajaran Kontekstual Berbasis Demonstrasi dalam Meningkatkan Hasil Belajar IPA dan Kemampuan Literasi Sains Siswa. *Cokroaminoto Journal of Primary Education*, 7(2), 495-505. https://doi.org/10.30605/cjpe.7.2.2024.4730

Primadianningsih, C., Sumarni, W., & Sudarmin, S. (2023). Systematic literature review: analysis of ethno-STEM and students' chemistry literacy profile in 21st century. *Jurnal Penelitian Pendidikan IPA*, 9(2), 650-659. 10.29303/jppipa.v9i2.2559

Rahmawati, A. D., Ardianzah, F., & Supriyanto, D. H. (2025). Systematic Literature Review: Helping Students Learn Mathematics through the Integrated Flipped Learning Model of Ethnomathematics and STEM. *Architecture Image Studies*, 6(4), 650-660. https://doi.org/10.62754/ais.v6i4.664

Ramadhan, E. H., & Hindun, H. (2023). Penerapan Model Pembelajaran Berbasis Proyek untuk Membantu Siswa Berpikir Kreatif. Protasis: *Jurnal Bahasa, Sastra, Budaya, dan Pengajarannya*, 2(2), 43-54. https://doi.org/10.55606/protasis.v2i2.98

Rohman, M. H., Marwoto, P., Nugroho, S. E., & Supriyadi, S. (2024). Effectiveness of ethnoecological-STEM project-based learning model to improve critical thinking skills, creativity, and science concept mastery. *International Journal of Cognitive Research in Science, Engineering and Education*, 12(3), 521-534. 10.23947/2334-8496-2024-12-3-521-534

Runco, M. A. (2014). Creativity: Theories and themes. Research, development, and practice, 152.

Runco, M. A., & Jaeger, G. J. (2012). The standard definition of creativity. *Creativity research journal*, 24(1), 92-96.

Sumarni, W., & Kadarwati, S. (2020). Ethno-stem project-based learning: Its impact to critical and creative thinking skills. *Jurnal Pendidikan IPA Indonesia*, 9(1), 11-21. 10.15294/jpii.v9i1.21754

Sudarmin, S., Pujiastuti, R. S. E., Asyhar, R., Prasetya, A. T., Diliarosta, S., & Ariyatun, A. (2023). Chemistry project-based learning for secondary metabolite course with ethno-STEM approach to improve students' conservation and entrepreneurial character in the 21st century. *JOTSE*, 13(1), 393-409.

Tijani, B. E., & Adeduyigbe, A. M. (2026). Transforming science education: A systematic review of evidence-based strategies for cultivating 21st-century skills in STEM education. *Journal of Research in Environmental and Science Education*, 3(1), 8-23. https://doi.org/10.70232/jrese.v3i1.37

Silver, N., Kaplan, M., LaVaque-Manty, D., & Meizlish, D. (Eds.). (2023). Using reflection and metacognition to improve student learning: Across the disciplines, across the academy. *Taylor & Francis*.

Susilawati, Ramalis, T. R., Kaniawati, I., & Rusdiana, D. (2021, June). Connections between prior knowledge and collaborative skill on discussion group about solar system related to descriptive scientific reasoning. *In Journal of Physics: Conference Series* (Vol. 1918, No. 5, p. 052052). IOP Publishing. 10.1088/1742-6596/1918/5/052052

Ummah, S. K., In'am, A., & Azmi, R. D. (2019). Creating Manipulatives: Improving Students' Creativity through Project-Based Learning. *Journal on Mathematics Education*, 10(1), 93-102.

Vincent-Lancrin, S. (2022). Fostering students' creativity and critical thinking in science education. In Education in the 21st century: STEM, creativity and critical thinking (pp. 29-47). *Cham: Springer International Publishing.* https://doi.org/10.1007/978-3-030-85300-6_3