

## **Developing Disaster Literacy through STEM-Ethnoscience Integration: Evidence from Primary School Contexts**

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### **Abstract**

Disaster literacy is an essential competency for primary school students, particularly in disaster-prone regions; however, it is often not optimally integrated into classroom learning. This study aims to examine the effectiveness of integrating STEM (Science, Technology, Engineering, and Mathematics) with ethnoscience to enhance disaster literacy among primary school students. The research employed a quasi-experimental design involving elementary students selected through purposive sampling. Data were collected through tests, questionnaires, and observations to measure students' knowledge, awareness, and preparedness related to disaster risk. The main statistical analyses used were the t-test and N-gain to compare disaster literacy between groups. The learning intervention integrated local wisdom (ethnoscience) into problem-oriented STEM activities relevant to students' real-life contexts. The results showed a significant difference in disaster literacy between the experimental and control groups, with  $t(58) = 3.27$  and  $p = 0.002$  ( $p < 0.05$ ). The experimental group demonstrated higher improvement (N-gain = 0.62; moderate category) compared to the control group (N-gain = 0.29; low category). These findings indicate that STEM-ethnoscience learning significantly improves students' disaster literacy. This approach also provides a meaningful and culturally relevant framework for disaster education. In conclusion, the STEM-ethnoscience approach is an effective and innovative pedagogical strategy for enhancing disaster awareness and preparedness in primary education.

**Keywords: Disaster Literacy; STEM Education; Ethnoscience; Primary School; Local Wisdom**

### **Introduction**

Disaster literacy has become an essential competency for primary school students, particularly in countries that are highly vulnerable to natural disasters. However, disaster education is often not optimally integrated into elementary learning processes, resulting in limited student understanding, awareness, and preparedness in facing disaster risks. Previous studies indicate that disaster education tends to be delivered theoretically and lacks contextual relevance to students' daily lives (Hoffmann and Blecha, 2020). In addition, the integration of science learning with local knowledge remains underutilized, even though local communities possess rich ethnoscientific knowledge related to disaster mitigation. Several studies have highlighted the importance of culturally responsive learning approaches, such as ethnoscience, in strengthening students' conceptual understanding (Ogunniyi, 2023). Meanwhile, STEM (Science, Technology, Engineering, and Mathematics) education has been widely recognized as an effective approach to develop critical thinking, problem-solving skills, and real-world application of knowledge (Kotsis, 2025). However, limited studies have explored the integration of STEM and ethnoscience in the context of disaster literacy at the primary education level.

Therefore, this study positions itself as an effort to bridge this gap by integrating STEM and ethnoscience to enhance disaster literacy among young learners. The urgency

of this study lies in the increasing frequency and impact of natural disasters, which demand early preparedness and awareness among students. Disaster literacy is not only about knowledge but also includes attitudes and skills necessary for effective disaster risk reduction. Integrating ethnoscience into STEM learning provides a meaningful and contextually relevant approach, enabling students to connect scientific concepts with local wisdom and real-life experiences. This approach is expected to foster a deeper understanding of disaster risks and encourage proactive behavior in disaster preparedness. Therefore, this study aims to examine the effectiveness of a STEM-ethnoscience integrated learning approach in improving disaster literacy among primary school students, as well as to contribute to the development of innovative and culturally relevant pedagogical strategies in disaster education.

To address these issues, this study employs a quasi-experimental research design with a mixed-methods approach. The research involves primary school students selected through purposive sampling. Data are collected using tests, questionnaires, and observations to measure students' knowledge, awareness, and preparedness related to disaster risk. The learning intervention is designed by integrating ethnoscience (local wisdom) into STEM-based, problem-oriented learning activities. This methodological approach is expected to provide comprehensive insights into the effectiveness of the proposed learning model in enhancing disaster literacy among primary school students.

A review of previous studies reveals a significant research gap, particularly in the integration of contextual and holistic learning approaches to enhance disaster literacy at the primary school level. Most existing studies still focus on delivering disaster-related knowledge in a theoretical and fragmented manner, without simultaneously integrating critical thinking skills, problem-solving abilities, and students' local contexts (Kurniawan and Hidayat, 2025). Furthermore, although the ethnoscience approach has been shown to improve conceptual understanding through its connection to culture and local wisdom, its implementation remains limited and has not been systematically combined with STEM frameworks that emphasize real-world problem solving (Widowati et al., 2023).

On the other hand, studies on STEM education tend to emphasize the development of 21st-century skills without being specifically oriented toward disaster contexts, particularly at the primary education level, which requires pedagogical approaches that are adaptive to students' developmental characteristics (Fitri et al., 2024). Therefore, the absence of an integrative learning model that explicitly combines STEM and ethnoscience within the context of disaster literacy indicates both theoretical and practical gaps that need to be addressed through more comprehensive and contextually grounded research.

Most studies tend to position disaster literacy as a theoretical transfer of knowledge and place less emphasis on its connection to students' real-life experiences, resulting in low levels of concept internalization and preparedness (Dare et al., 2021). In addition, although efforts have been made to integrate science learning with local wisdom through an ethnoscience approach, its implementation remains limited to enhancing conceptual understanding and has not been specifically directed toward disaster contexts (Sihombing et al., 2025). On the other hand, the STEM approach has been widely studied for its effectiveness in improving critical thinking and problem-solving skills; however, these studies generally do not accommodate local contexts or the specific needs of disaster literacy at the primary school level (Imron et al., 2025). Furthermore, there is still a lack of studies that systematically integrate STEM and ethnoscience within a comprehensive and contextual learning framework to enhance disaster literacy among primary school students. This indicates a clear research gap, particularly in the development of innovative learning models that not only focus on cognitive aspects but also encompass attitudes and preparedness skills grounded in local contexts.

This study is grounded in the problem of the limited development of learning models that systematically integrate STEM and ethnoscience approaches to enhance disaster literacy among primary school students, encompassing aspects of knowledge, attitudes, and preparedness skills that are contextual and aligned with students' developmental characteristics. Therefore, the research problem is focused on examining how effective the integration of STEM and ethnoscience is in improving disaster literacy among primary school students, to what extent this approach enhances students' knowledge related to disasters, how it influences students' attitudes toward disaster risks, and how far it can improve students' preparedness skills. In addition, this study also investigates how a contextual and adaptive STEM-ethnoscience learning model can be implemented in disaster education at the primary school level.

## Method

This study employed a quasi-experimental design with a mixed-methods approach to examine the effectiveness of STEM-ethnoscience integrated learning in improving disaster literacy among primary school students. The research was conducted in an elementary school involving two groups, namely an experimental group and a control group, selected through purposive sampling based on similar academic characteristics. The experimental group received STEM-ethnoscience-based learning, while the control group was taught using conventional methods. The data sources included students and classroom learning activities. The types of data collected consisted of students' disaster literacy knowledge, awareness, preparedness, learning engagement, and responses to the learning process. Data collection techniques included tests (pre-test and post-test), questionnaires, observations, and interviews supported by instruments such as test items, Likert-scale questionnaires, observation sheets, and interview guidelines. Quantitative data were analyzed using descriptive statistics, N-gain, and t-tests to determine the effectiveness of the intervention, while qualitative data were analyzed through data reduction, data display, and conclusion.

## Results and Discussion

The findings of this study reveal that the integration of STEM-ethnoscience learning significantly improves disaster literacy among primary school students. The analysis was conducted based on students' knowledge, awareness, preparedness, and engagement during the learning process. The results show that students exposed to STEM-ethnoscience learning demonstrate better performance compared to those who experienced conventional instruction. This supports the notion that meaningful and contextual learning enhances students' understanding of real-world problems (Atmojo et al., 2025). Based on the pre-test and post-test scores, there was a notable improvement in the experimental group. The average pre-test score of the experimental group was 55.2, which increased to 82.6 in the post-test, while the control group improved from 54.8 to 68.3. The N-gain analysis indicates that the experimental group achieved a moderate-to-high improvement (0.62), whereas the control group showed a low-to-moderate improvement (0.29). This suggests that STEM-ethnoscience learning is more effective in enhancing students' disaster literacy.

Table 1. Pre-test, Post-test, and N-gain Scores

Group	Pre-test Mean	Post-test Mean	N-gain	Category
Experimental	55.2	82.6	0.62	Moderate
Control	54.8	68.3	0.29	Low

The t-test results indicate a significant effect on disaster literacy, with  $t(58) = 3.27$  and  $p = 0.002$  ( $p < 0.05$ ). These findings align with previous research stating that STEM-based learning improves conceptual understanding and problem-solving skills (Astuti, N. H et al., 2021). The addition of ethnoscience further strengthens this effect by providing cultural relevance to the learning process (Hikmawati et al., 2021). In terms of disaster awareness, the questionnaire results indicate a significant increase in students' awareness levels in the experimental group. Students demonstrated a better understanding of disaster risks, early warning signs, and mitigation strategies.

The average awareness score increased from 65% to 88% in the experimental group, compared to 66% to 74% in the control group. This finding supports the argument that contextual learning enhances students' awareness and engagement (Jasper-Abowei and Victor-Ishikaku, 2023). Similarly, students' preparedness showed improvement after the intervention. The experimental group demonstrated higher preparedness levels, particularly in identifying evacuation procedures and safety measures during disasters. This result highlights the importance of integrating real-life problem-solving activities into classroom learning to build practical skills (Dare et al., 2021).

Observational data further revealed that students in the experimental group were more actively engaged during the learning process. They participated in discussions, collaborated in group activities, and showed enthusiasm in solving disaster-related problems. This supports the idea that active learning environments foster deeper understanding and student motivation (Rezai et al., 2025). The integration of ethnoscience played a crucial role in enhancing students' learning experiences. By incorporating local wisdom, such as traditional knowledge of disaster signs and mitigation practices, students were able to relate scientific concepts to their daily lives. This finding is consistent with studies emphasizing the importance of culturally responsive pedagogy (Ulbricht et al., 2024).

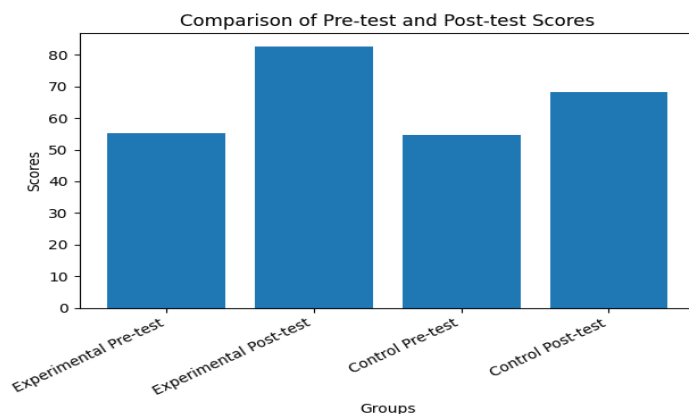


Figure 1. Comparison of Pre-test and Post-test Scores

The figure above illustrates the significant improvement in the experimental group compared to the control group. The visual representation confirms that STEM-ethnoscience learning leads to higher learning gains. This approach not only improves cognitive outcomes but also enhances affective and behavioral aspects of disaster literacy. Furthermore, students' responses indicated positive perceptions of the learning model. Most students expressed that the learning activities were interesting, relevant, and helpful in understanding disaster-related concepts. This suggests that integrating STEM with ethnoscience creates an engaging and meaningful learning environment (Listiyani et al., 2025). Overall, the findings of this study confirm that STEM-ethnoscience learning is an effective approach to improving disaster literacy in primary education. The integration of local knowledge with scientific learning provides a holistic understanding that enhances students' knowledge, awareness, and preparedness. Therefore, this study contributes to

the development of innovative and culturally relevant disaster education strategies that can be implemented in primary schools. To address the growing need for effective disaster education in hazard-prone regions, particularly in primary schools, it is essential to develop a learning model that is both scientifically grounded and contextually relevant. Traditional approaches to disaster education often emphasize theoretical knowledge while overlooking the rich potential of local wisdom as a meaningful learning resource. Integrating ethnoscience with STEM (Science, Technology, Engineering, and Mathematics) offers a promising pathway to bridge this gap by connecting indigenous knowledge systems with modern scientific understanding.

Such integration not only enhances students' conceptual comprehension but also fosters critical thinking, problem-solving skills, and real-world application in disaster contexts (Yamwongsri and Chen, 2025). Therefore, the following diagram presents a systematic framework illustrating how local wisdom can be identified, integrated into STEM-based learning, and implemented through contextual instructional design to ultimately improve students' disaster literacy and resilience.

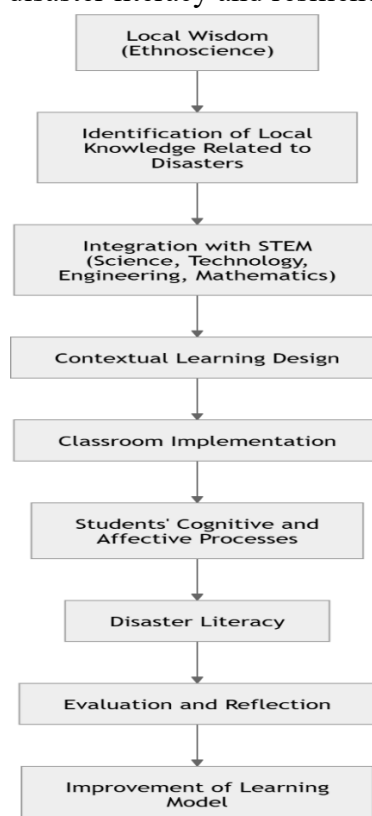


Figure 2. A Conceptual Framework of STEM-Ethnoscience Integrated Learning for Enhancing Students' Disaster Literacy

The diagram illustrates a systematic and iterative framework for developing and implementing a STEM-ethnoscience integrated learning model in disaster education. This model emphasizes the transformation of local knowledge into structured scientific learning experiences that ultimately enhance students' disaster literacy. The process is both linear and cyclical, reflecting continuous improvement based on evaluation outcomes. The process begins with local wisdom (ethnoscience), which serves as the foundational knowledge base. Ethnoscience represents community-based knowledge systems that have evolved through long-term interaction with the natural environment.

Such knowledge is often context-specific and empirically grounded, making it highly relevant for disaster education. Previous studies highlight that integrating local wisdom into formal education enhances contextual understanding and cultural relevance

of learning (Rahim and Fauzi, 2023). The next stage involves the identification of local knowledge related to disasters. This phase is exploratory and analytical, aiming to document indigenous practices, beliefs, and mitigation strategies associated with natural hazards such as volcanic eruptions.

The identification process ensures that selected knowledge aligns with scientific principles and educational objectives. According to Vasileiou et al., (2022) local knowledge plays a critical role in disaster risk reduction, particularly in communities exposed to recurring hazards. Following identification, the model proceeds to integration with STEM (Science, Technology, Engineering, and Mathematics). At this stage, local knowledge is conceptually linked with scientific theories and practices. This integration allows students to understand disaster phenomena not only from a cultural perspective but also through scientific reasoning, technological applications, and engineering solutions.

Research by Sata (2024) emphasizes that STEM integration fosters problem-solving skills and supports interdisciplinary learning, which is essential in addressing complex real-world issues such as disasters. The integrated content is then translated into a contextual learning design. This design adopts student-centered approaches, such as problem-based learning and inquiry-based learning, which connect instructional materials to students' real-life experiences. Contextual learning has been shown to improve engagement and knowledge retention by making learning meaningful and relevant (Joshi, 2026). The next phase is classroom implementation, where the designed learning activities are enacted. Teachers function as facilitators, guiding students through active learning processes such as experiments, simulations, and project-based tasks related to disaster scenarios. Effective implementation of STEM-based learning has been associated with improved critical thinking and collaborative skills (Bulu and Tanggur, 2021). During implementation, students undergo cognitive and affective processes. Cognitively, students develop conceptual understanding, analytical thinking, and problem-solving abilities.

Affectively, they build awareness, attitudes, and preparedness toward disaster risks. Bloom's taxonomy supports the integration of cognitive and affective domains in achieving comprehensive learning outcomes (Sori et al., 2025). These processes lead to the development of students' disaster literacy, which includes knowledge, skills, and attitudes necessary to understand, respond to, and mitigate disaster risks. Disaster literacy is increasingly recognized as a crucial component of education in hazard-prone regions, as it enhances individual and community resilience (Rahma et al., 2025).

Subsequently, the model incorporates evaluation and reflection, which assess the effectiveness of the learning process. Evaluation is conducted across multiple dimensions, including students' knowledge, attitudes, and skills. Reflection enables educators to critically examine instructional practices and identify areas for improvement. Formative and summative assessments are essential in ensuring the quality of educational interventions (Mustamin, 2024). Finally, the process culminates in the improvement of the learning model, highlighting its dynamic and adaptive nature. Feedback from evaluation informs revisions to instructional design, content integration, and implementation strategies. This continuous improvement cycle ensures that the model remains relevant, effective, and responsive to students' needs and contextual challenges. In conclusion, the diagram demonstrates that the integration of ethnoscience and STEM provides a comprehensive, contextual, and sustainable approach to disaster education.

By bridging local wisdom with scientific knowledge, this model not only enhances students' academic understanding but also strengthens their preparedness and resilience in facing disaster risks. The results of the study indicate that the integration of

STEM and ethnoscience significantly improves students' disaster literacy, as reflected in the differences between pre-test and post-test scores and the higher N-gain values in the experimental group. Theoretically, these findings can be explained through the constructivist learning framework, which emphasizes that knowledge is actively constructed through meaningful and contextual learning experiences.

The integration of ethnoscience enables students to relate scientific concepts to familiar local wisdom, thereby strengthening conceptual understanding and learning relevance (Topsakal et al., 2025). Meanwhile, the STEM approach promotes student engagement in real-world problem solving, contributing to the development of critical thinking skills and disaster preparedness (Chasokela, 2025). Thus, the combination of these two approaches not only enhances cognitive aspects but also fosters awareness and responsive attitudes toward disaster risks, which are essential components of disaster literacy. However, these findings should be critically examined by considering the limitations of the study and potential biases that may have influenced the results.

The quasi-experimental design employed still has limitations in controlling external variables, such as differences in students' initial characteristics and learning environments, which may affect the intervention outcomes. In addition, although a significant improvement was observed, it remains uncertain to what extent these effects are sustained in the long term, particularly in shaping students' preparedness behaviors in real-life situations. When compared with previous studies, these findings are consistent with research indicating that context- and culture-based learning can significantly enhance students' understanding; however, challenges remain in integrating such approaches consistently into classroom practice (Tuong et al., 2023).

Therefore, further research employing longitudinal designs and more integrated mixed-methods approaches is needed to provide a more comprehensive understanding of the effectiveness and sustainability of the STEM-ethnoscience learning model in improving disaster literacy among primary school students. From a theoretical perspective, the effectiveness of integrating STEM and ethnoscience in enhancing disaster literacy can be explained through the lenses of social constructivism and contextual learning, which emphasize that knowledge is constructed through the interaction between students' experiences, culture, and learning environments.

Within this framework, ethnoscience serves as a bridge connecting scientific concepts with local wisdom, enabling meaningful and relevant learning experiences (Dzaiy and Abdullah, 2024). Meanwhile, the STEM approach strengthens this process through real-world problem-based activities that encourage students to develop critical, collaborative, and problem-solving skills (Cruz et al., 2025). The integration of these approaches aligns with situated learning theory, which positions context as a key element in learning, where understanding becomes deeper when students are directly engaged in situations resembling real-life conditions (Putri et al., 2024). Therefore, the combination of STEM and ethnoscience not only enriches students' cognitive learning experiences but also strengthens affective and psychomotor dimensions that are crucial for building disaster preparedness.

Compared to previous studies, these findings demonstrate a more comprehensive contribution to improving disaster literacy among primary school students. The study by Cong and Ironsi (2025) highlights that disaster education based on local contexts can enhance students' understanding, yet it remains limited to cognitive aspects and does not systematically develop preparedness skills. Similarly et al., (2025) show that the integration of local wisdom through an ethnoscience approach effectively strengthens conceptual understanding, but it has not been combined with problem-solving-based approaches such as STEM.

On the other hand, Viduya-Galo and Nabua (2026) emphasize the strengths of STEM in developing critical thinking and problem-solving skills but pay limited attention to cultural context and local relevance. Therefore, this study offers a more integrative approach by simultaneously combining the strengths of ethnoscience and STEM, thereby not only enhancing conceptual understanding but also improving students' attitudes and preparedness skills in a more contextual manner. Thus, the findings of this study not only confirm previous research but also extend it through a more holistic and applicable approach within the context of disaster literacy in primary education.

## Conclusion

This study provides a deeper conceptual synthesis by demonstrating that the integration of STEM and ethnoscience constitutes a coherent and context-based learning framework capable of enhancing disaster literacy among elementary school students. Findings indicate that disaster literacy is not merely a cognitive construct but a multidimensional competency encompassing knowledge, attitudes, and preparedness skills, effectively built through meaningful, experiential learning. By situating scientific concepts within a local cultural context, the STEM-ethnoscience approach aligns with constructivist and situated learning theories, emphasizing that knowledge is built through active engagement with real-world problems and socio-cultural environments. This integrative framework extends existing theory by highlighting the importance of combining global scientific perspectives with local wisdom to cultivate adaptive and resilient learners in disaster-prone contexts. From a practical perspective, this study contributes to the development of an innovative and applicable learning model that can be implemented in elementary education to strengthen disaster preparedness. The proposed STEM-ethnoscience model offers a structured yet flexible pedagogical approach that can be adapted to diverse local contexts, thus supporting teachers in designing more relevant and engaging learning experiences. Furthermore, these findings have important implications for education policy, particularly in advocating for the systematic integration of disaster education into the primary school curriculum through an interdisciplinary and culturally responsive approach. Policymakers are encouraged to incorporate these models into curriculum design, teacher training programs, and disaster risk reduction strategies in education, to ensure that students are not only knowledgeable but also equipped with the skills and attitudes necessary to respond effectively to disaster risks.

## References

- Astuti, N. H., Rusilowati, A., & Subali, B. (2021). STEM-Based Learning Analysis To Improve Students' Problem Solving Abilities In Science Subject: A Literature Review. *Journal of Innovative Science Education*, 10(1), 79-86.
- Atmojo, S. E., Anggriani, M. D., Rahmawati, R. D., Skotnicka, M., Wardana, A. K., & Anindya, A. P. (2025). Bridging STEM And Culture: The Role Of Ethnoscience In Developing Critical Thinking And Cultural Literacy. *Jurnal Pendidikan IPA Indonesia*, 14(20), 251-266.
- Bulu, V. R., & Tanggur, F. (2021). The Effectiveness of STEM-Based PjBL On Student's Critical Thinking Skills And Collaborative Attitude. *Al-Jabar: Jurnal Pendidikan Matematika*, 12(1), 219-228.
- Chasokela, D. (2025). Investigating The Role Of Virtual Reality To Support Student'engagement, Spatial Awareness And Problem-Solving Skills In Engineering Education. *International Journal of Instruction*, 18(3), 613-636.

- Cong, L., & Ironsi, C. S. (2025). Integrating Mobile Learning And Problem-Based Learning In Improving Students Action Competence In Problem-Solving And Critical Thinking Skills. *Humanities and Social Sciences Communications*, 12(1), 1-11.
- Cruz, L. D., Aguinaldo, I., Alzate, L. J., Camero, C., Abiado, K. R., & Gumpal, B. (2025). Fostering Intercultural Competence Through Culturally Responsive Pedagogy: Practices And Perspectives In Philippine Higher Education Institutions. *International Journal on Culture, History, and Religion*, 7(S12), 36-50.
- Dare, E. A., Keratithamkul, K., Hiwatig, B. M., & Li, F. (2021). Beyond Content: The Role Of STEM Disciplines, Real-World Problems, 21st Century Skills, And STEM Careers Within Science Teachers' Conceptions Of Integrated STEM Education. *Education Sciences*, 11(11), 737-748.
- Dzaiy, A. H. S., & Abdullah, S. A. (2024). The Use Of Active Learning Strategies To Foster Effective Teaching In Higher Education Institutions. *Zanco Journal of Human Sciences*, 28(4), 328-351.
- Fitri, H. S. A., Agustin, E. P., Chuchai, S., Joronalona, R., & Ali, S. (2024). Trends in Culturally Responsive Teaching for Science Education: A Bibliometric Analysis. *Journal of Technological Pedagogy and Educational Development*, 1(2), 36-52.
- Fitria, D., Asrizal, A., Lufri, L., & Handrianto, C. (2025). Integrating Blended Problem-Based Learning with Ethnoscience to Develop Twenty-First-Century Skills. *The International Journal of Pedagogy and Curriculum*, 32(2), 165-174.
- Hikmawati, H., Suastra, I. W., & Pujani, N. M. (2021). Ethnoscience-Based Science Learning Model To Develop Critical Thinking Ability And Local Cultural Concern For Junior High School Students In Lombok. *Jurnal Penelitian Pendidikan IPA*, 7(1), 60-66.
- Hoffmann, R., & Blecha, D. (2020). Education And Disaster Vulnerability In Southeast Asia: Evidence And Policy Implications. *Sustainability*, 12(4), 1401-1412.
- Imron, E. M., Nugraheni, F. S. A., Utami, B., Nursalsabila, Z., Mahardiani, L., & Tanghal, A. B. (2025). Effectiveness of Ethno-STEM-Based Science Teaching With The Project-Based Learning Model on Students' Scientific Literacy. *Jurnal Inovasi Pendidikan IPA*, 11(2), 435-453.
- Jasper-Abowei, F. E., & Victor-Ishikaku, E. C. (2023). Contextual Learning Approach: A Tool For Enhancing Critical Thinking Skills Amongst Learners'. *Central Asian Journal of Social Sciences and History*, 4(5), 72-83.
- Joshi, A. S. (2026). Transforming Learning Experiences: A Case Study of Integrating Contextual Teaching and Learning (CTL) in the Physics Course within a Bachelor of Technology Program. *Journal of Engineering Education Transformations*, 39(3), 86-97.
- Kotsis, K. T. (2025). Inquiry-Based Learning In Science: Mathematical Reasoning's Support Of Critical Thinking. *Journal of Research in Mathematics, Science, and Technology Education*, 2(1), 60-72.
- Kurniawan, N., & Hidayat, A. N. (2025). Integrating Disaster Education Into Geography Curriculum: Strengthening School-Based Preparedness. *Journal of Environment and Geography Education*, 2(1), 45-58.
- Listiyani, L. R., Wilujeng, I., Suyanto, S., & Pratama, D. H. (2025). EthnoSTEM-based Learning Tools: Connecting Cultural Heritage with STEM Education. *International Electronic Journal of Elementary Education*, 17(4), 593-609.

- Mustamin, R. (2024). The Role Of Formative And Summative Assessment In Improving Learning Quality And Student Learning Outcomes. *Journal of Strategy and Transformation in Educational Management*, 1(1), 17-21.
- Ogunniyi, M. M. (2023). *Culturally Responsive Science Education For Indigenous And Ethnic Minority Students*. London: Routledge.
- Putri, R. A. R. Q. Y., Jasruddin, J., & Mustafa, M. (2024). The Relationship Between Ethnoscience and Creative Thinking Skills to Support 21st Century Learning for High School Student in West Sulawesi: Literature Review. *International Journal of Current Science Research and Review*, 7(11), 8442-8446
- Rahim, F. R., & Fauzi, A. (2023). Fostering Creative Problem Solving Skills Through Integrated Learning Of Volcanic Eruption Disasters. *ASEAN Natural Disaster Mitigation and Education Journal*, 1(1), 31-42.
- Rahma, A., Rizkiyani, F., & Yunia Sari, D. (2025). Exploring Disaster Literacy: Early Childhood Education Teachers' Perspective On School Safety. *Early Years*, 45(5)1-19.
- Rezai, A., Ahmadi, R., Ashkani, P., & Hosseini, G. H. (2025). Implementing Active Learning Approach To Promote Motivation, Reduce Anxiety, And Shape Positive Attitudes: A Case Study of EFL Learners. *Acta Psychologica*, 253(1), 104704-104715.
- Sata, S. K. (2024). Advancing Analytical and Problem-Solving Skills for STEM-Related Challenges: Exploring Innovative Educational Strategies and Practical Applications. *World Journal of Arts, Education and Literature*, 1(2), 32-38.
- Sihombing, R. A., Anwar, S., Liu, S. Y., Muslim, M., Winarno, N., & Sihombing, P. J. (2025). Integrating Local Wisdom Into Environmental Education: A Systematic Review Of Ethnoscience Research In Indonesia. *Journal of Natural Science and Integration*, 8(1), 57-74.
- Sori, Z. M., Mustapha, W. H. W., & Mustaffa, M. A. M. (2025). Bloom's Taxonomy for Effective Teaching and Learning. *Bloom's Taxonomy for Effective Teaching and Learning (January 28, 2025)*.
- Topsakal, İ., Yalçın, S. A., & Çakır, Z. (2022). The Effect Of Problem-Based STEM Education On The Students' Critical Thinking Tendencies And Their Perceptions For Problem Solving Skills. *Science Education International*, 33(2), 136-145.
- Tuong, H. A., Nam, P. S., Hau, N. H., Tien, V. T. B., Lavicza, Z., & Houghton, T. (2023). Utilizing STEM-Based Practices To Enhance Mathematics Teaching In Vietnam: Developing Students' Real-World Problem Solving And 21st Century Skills. *JOTSE: Journal of Technology and Science Education*, 13(1), 73-91.
- Ulbricht, J., Schachner, M. K., Civitillo, S., & Juang, L. (2024). Fostering Culturally Responsive Teaching Through The Identity Project Intervention: A Qualitative Quasi-Experiment With Pre-Service Teachers. *Identity*, 24(4), 307-330.
- Vasileiou, K., Barnett, J., & Fraser, D. S. (2022). Integrating Local And Scientific Knowledge In Disaster Risk Reduction: A Systematic Review Of Motivations, Processes, And Outcomes. *International Journal of Disaster Risk Reduction*, 81(1), 103255-103267.
- Viduya-Galo, M. A., & Nabua, E. B. (2026). Bridging Culture and Chemistry: Assessing Grade 9 Learners' Cultural awareness and Conceptual Understanding for an Ethno Chemical Learning Module. *International Journal of Research in Social Science and Humanities (IJRSS) ISSN: 2582-6220, DOI: 10.47505/IJRSS*, 7(1), 273-284.
- Widowati, E., Koesyanto, H., Istiono, W., Sutomo, A. H., & Sugiharto, S. (2023). Disaster Preparedness And Safety School As A Conceptual Framework Of Comprehensive School Safety. *Sage Open*, 13(4), 1-11.

Yamwongsri, P., & Chen, H. L. (2025). The Effects of Spherical Video-Based Virtual Reality in Inquiry-Based Learning on Student Learning Outcomes, Higher-Order Thinking, and Learning Experiences in Geography Education. *Journal of Educational Computing Research*, 63(6), 1550-1579.