pISSN 2685-0761
eISSN 2685-0850

JURNAL INOVASI PEMBELAJARAN KIMIA
(Journal of Innovation in Chemistry Education)
https://jurnal.unimed.ac.id/2012/index.php/jipk
email: Jinovpkim@unimed.ac.id

Recieved : 19 September 2026
Revised : 01 October 2026
Accepted : 29 October 2026
Published : 31 October 2026
Pages : 338 – 348

Pedagogical Readiness of Chemistry Teachers in Implementing Ethno-STEM Learning

Fahmi Ali[1]*, Masrid Pikoli[2], Netty Ino Ischak[3], Akram La Kilo[4], Yuszda K. Salimi[5], and Deasy Natalia Botutihe[6]

[1] *Master Program of Chemistry Education, Postgraduate Program, Universitas Negeri Gorontalo, Indonesia*

[2,3,4,5,6] *Department of Chemistry Education, Postgraduate Program, Universitas Negeri Gorontalo, Gorontalo, Indonesia*

*Email: fahmiali252023@gmail.com

Abstract: *Ethno-STEM learning connects chemistry concepts with local cultural knowledge and students' everyday experiences. However, its implementation depends on teachers' pedagogical readiness to understand the approach, design contextual learning, and translate local knowledge into classroom practice. Although Ethno-STEM has been increasingly discussed for integrating cultural contexts into science education, empirical evidence on chemistry teachers' readiness to implement it, particularly in Gorontalo, remains limited. This study analyzed the pedagogical readiness of chemistry teachers in implementing Ethno-STEM learning in Gorontalo. A qualitative descriptive-exploratory approach was employed with 13 chemistry teachers from public senior high schools, selected purposively. Data were collected through in-depth semi-structured interviews and documentation and analyzed thematically. The findings show that teachers' pedagogical readiness remains transitional. Most teachers had not developed a comprehensive understanding of Ethno-STEM, although they demonstrated awareness of local cultural potential and the relevance of contextual chemistry learning. Teachers were generally willing to implement Ethno-STEM, but their ability to translate contextual ideas into systematic instructional plans remained limited. The study concludes that teachers possess positive contextual and affective foundations but require targeted professional development to strengthen the operational competence needed for systematic implementation. Future research should develop practical tools that help teachers translate local cultural knowledge into chemistry learning.*

Keywords: *pedagogical readiness; chemistry teachers; Ethno-STEM; local wisdom; chemistry education*

INTRODUCTION

Science education at the secondary school level is expected not only to develop students' conceptual understanding but also to strengthen scientific process skills and the ability to apply science to everyday problems. In the context of the Merdeka Curriculum, students are expected to use scientific knowledge to address real-life situations rather than merely memorize theories. Ethno-STEM (Ethnoscience, Science, Technology, Engineering, and Mathematics) responds to this need by connecting modern science with local knowledge and cultural practices,

making learning more contextual and meaningful (Kelley and Knowles, 2016; Atmojo et al., 2025).

The success of Ethno-STEM implementation is strongly influenced by teachers' pedagogical readiness, particularly their ability to combine chemistry content knowledge with pedagogical content knowledge so that abstract chemistry concepts can be connected systematically with students' cultural and environmental experiences (Masayu, 2024; Yue et al., 2024). Research on integrated STEM shows that teachers' attitudes, school context, and understanding of STEM principles influence instructional practice (Thibaut et al., 2018; Margot & Kettler, 2019; Alagoz & Canli, 2024). Findings from chemistry teacher research on TPACK also show that pedagogical, content, and technological knowledge need to be integrated in teachers' instructional practice (Sutiani et al., 2022). Although teachers generally recognize the value of STEM, they may still face pedagogical, curricular, assessment, and professional-development challenges (Aslam et al., 2023; Syofyan et al., 2024).

Previous studies also show that teacher readiness for STEM and ethnoscience learning is uneven. Teachers may understand STEM at a broad level but have limited experience in designing and implementing integrated STEM learning (Sulaeman et al., 2022; Talib et al., 2024; Ekayanti et al., 2025). Teachers can also experience difficulties in preparing learning plans, teaching materials, and assessment instruments for ethnoscience-oriented learning (Rahmawan et al., 2023; Festiyed et al., 2022). Research published in JIPK likewise indicates a need for innovative chemistry teaching materials integrated with ethnopedagogy to support contextual and 21st-century learning (Siswanto et al., 2025). Professional development has been identified as an important support for strengthening teachers' capacity to move from general awareness toward practical implementation.

Gorontalo provides a relevant context for Ethno-STEM because local cultural knowledge remains embedded in community life. Local wisdom can be developed as part of science learning so that chemistry concepts become closer to students' lived experiences (Ihsan et al., 2024; Sanova et al., 2021). Gorontalo cultural values, including huyula, also have potential to support the development of empathy, tolerance, and social responsibility through education (Dali and Yunus, 2025). The continuing strength of local cultural identity amid globalization further supports its potential as a meaningful educational resource (Mohi, 2021).

Nevertheless, a gap remains between the availability of local cultural resources and teachers' pedagogical capacity to use them in chemistry learning. Integrating local wisdom into science requires teachers to connect traditional knowledge with formal scientific concepts (Sihombing et al., 2025; Hidayati and Julianto, 2025). The availability of appropriate learning resources is also important to support this integration, as chemistry learning media based on local wisdom can help connect contextual cultural knowledge with chemistry learning (Purba et al., 2024).

Recent studies demonstrate that Ethno-STEM can be implemented through chemistry learning resources and instructional tools, but much of the existing work focuses on student outcomes or product development rather than on teachers' readiness before implementation (Astuti et al., 2021; Izzania and Sumarni, 2024; Khoiriyah et al., 2025; Listiyani et al., 2025; Marpaung et al., 2025). This gap is particularly important in Gorontalo, where local cultural potential is strong but empirical evidence concerning chemistry teachers' readiness remains limited.

The novelty of this study lies in examining chemistry teachers' pedagogical readiness through three connected aspects: understanding of Ethno-STEM, ability to design Ethno-STEM learning, and professional readiness to implement the approach. The study therefore addresses the gap between teachers' positive orientation toward contextual learning and their actual

capacity to operationalize Ethno-STEM in chemistry instruction. The objective was to analyze the pedagogical readiness of chemistry teachers in implementing Ethno-STEM learning in Gorontalo. To achieve this objective, this study addresses the following research question: How do chemistry teachers in Gorontalo perceive their pedagogical readiness for Ethno-STEM implementation?

LITERATURE REVIEW

Pedagogical readiness is a multidimensional condition involving teachers' cognitive, affective, and operational preparedness to plan, implement, and evaluate learning (Menganti, 2023; Sodikin, 2022). In STEM education, readiness also involves teachers' understanding of integrated STEM principles, confidence, prior experience, and opportunities for professional learning (Sulaeman et al., 2022; Talib et al., 2024) Studies of teachers' perceptions indicate that teachers generally value STEM education but report barriers related to pedagogy, curriculum, assessment, school structures, and support (Margot and Kettler, 2019; Aslam et al., 2023).

Teacher readiness can also be strengthened through targeted professional development rather than through conceptual introduction alone. Evidence from STEM professional development shows that structured learning experiences can improve teachers' confidence, efficacy, perceptions, and attention to curriculum integration. Recent work on teacher learning for integrated STEM curriculum design likewise emphasizes opportunities to analyze resources, explore curriculum connections, and develop practical integrated designs (Ekayanti et al., 2025). This perspective supports the view that pedagogical readiness is not a fixed condition but a capacity that can be developed through sustained professional learning and contextual support.

Integrated STEM requires meaningful connections among disciplines and the use of inquiry, problem solving, design, and contextual learning. Kelley and Knowles (2016) proposed an integrated STEM framework that emphasizes connections among STEM disciplines and real-world problems. Thibaut et al. (2018) further showed that teachers' attitudes and school context can influence the implementation of integrated STEM practices. These findings indicate that teacher readiness should be examined not only as willingness but also as the capacity to enact the approach.

Ethno-STEM extends integrated STEM by connecting STEM learning with local or indigenous knowledge. The approach can strengthen the relevance of science learning because students encounter scientific concepts through cultural practices and environmental phenomena that are familiar to them (Atmojo et al., 2025; Wilujeng and Ungirwalu, 2024; Kamaludin et al., 2024). Studies of ethnoscience-based chemistry learning also show how local contexts can be connected to chemistry concepts through problem-based and contextual learning (Sanova et al., 2021). Recent JIPK research further demonstrates that ethnopedagogical chemistry materials can support meaningful learning and critical thinking when cultural contexts are systematically incorporated into instructional materials (Silaban et al., 2025).

In chemistry education, the development of Ethno-STEM resources has included e-modules, learning modules, tests, and electronic worksheets. Astuti et al. (2021) reported the use of blended inquiry learning with an Ethno-STEM approach in chemistry education, while (Izzania and Sumarni, 2024) developed an Ethno-STEM green chemistry e-module. Khoiriyah et al. (2025) developed an Ethno-STEM chemical literacy test instrument and an Ethno-STEM-based e-module for chemistry learning. Listiyani et al. (2025) also developed EthnoSTEM-based learning tools connecting cultural heritage with STEM education. In JIPK Ibrahim and Sutiani, (2025) demonstrated the development of a chemistry e-module integrating STEM and project-based learning, reinforcing the importance of structured learning resources for STEM-oriented chemistry instruction.

These studies demonstrate the instructional potential of Ethno-STEM but also highlight the need to understand the teacher competencies required to use such resources effectively.

Local wisdom provides the cultural foundation for contextualizing science. Studies have demonstrated that local knowledge can be mapped onto science concepts and transformed into teaching materials. In Gorontalo, local cultural resources have been identified as relevant materials for science learning (Ihsan et al., 2024; Sihombing et al., 2025). JIPK research in the Sitaro Islands likewise identified a need for chemistry learning media based on local wisdom, indicating that cultural context can be an important consideration in developing chemistry learning resources (Panggabean et al., 2023). The present study therefore positions pedagogical readiness as a bridge between the availability of local cultural knowledge and its systematic use in chemistry learning.

METHODS

Research Design

This study employed a qualitative descriptive-exploratory approach to examine chemistry teachers' pedagogical readiness in implementing Ethno-STEM learning. The approach was selected to capture teachers' understanding, experiences, and readiness in their natural school context, consistent with qualitative research design principles (Creswell, 2017; Sugiyono, 2022).

Participants and Setting

The research was conducted in public senior high schools in Gorontalo from February to May 2026. The participants were 13 chemistry teachers selected purposively based on their active teaching role, teaching experience, and representation of varied school contexts. Participant selection followed the principle of data adequacy, whereby information was considered sufficient when it became complementary and adequate to address the research focus.

Data Collection

Data were collected through in-depth semi-structured interviews and documentation. The interviews were conducted with chemistry teachers using an interview guide that had been validated by three experts consisting of two professors and one doctoral-level lecturer in chemistry education. The interviews were recorded using a mobile phone with participants' consent and subsequently transcribed verbatim into Microsoft Word for further analysis. The documentation data consisted of researcher and participant photographs during the research process. Although some teachers had previously implemented learning activities related to local contexts, relevant teaching documents such as lesson plans, teaching materials, or student worksheets were no longer available because these activities had been conducted approximately three to four years earlier and teachers had not yet identified them as Ethno-STEM-based learning practices..

Data Analysis

The data were analyzed thematically through comprehensive reading, open coding, grouping codes into themes, interpreting relationships among themes, and constructing the findings as an integrated narrative. The coding and thematic analysis process was assisted by ATLAS.ti qualitative data analysis software. The researcher conducted the coding process by identifying meaningful statements from interview transcripts, assigning initial codes, organizing related codes into categories, and developing themes related to chemistry teachers' pedagogical readiness in implementing Ethno-STEM learning. For this article, the analysis was limited to three dimensions of pedagogical readiness: understanding of Ethno-STEM (DP1), ability to design Ethno-STEM learning (DP2), and professional readiness (DP3). Thematic interpretation followed established qualitative analysis procedures (Miles, M. B., & Huberman, 1994; Sugiyono, 2022).

Trustworthiness

Data credibility was maintained through source triangulation, technique triangulation, member checking, prolonged engagement, analytical persistence, and peer debriefing. Interview findings were compared across participants and with available documentation, while member checking was used to confirm the interpretation of key statements. In addition, the interview protocol was validated by three experts in chemistry education, consisting of two professors and one doctoral-level lecturer, to ensure the relevance and clarity of the questions before data collection. The credibility of the findings was strengthened through systematic coding and thematic analysis using ATLAS.ti, allowing the researcher to maintain consistency in organizing and interpreting the qualitative data (Carter et al., 2014; Emil et al., 1985).

RESULT AND DISCUSSION

Analysis of interviews and documentation from the 13 chemistry teachers identified three dimensions of pedagogical readiness: (1) understanding of Ethno-STEM (DP1), (2) ability to design Ethno-STEM learning (DP2), and (3) professional readiness (DP3). The distribution of the coding results is presented in Table 1.

Table 1. Distribution of Chemistry Teachers' Pedagogical Readiness (DP1–DP3)

Code	Finding Category	n
DP1.1	Unfamiliar with Ethno-STEM	4
DP1.2	Familiar with STEM but not yet with Ethno-STEM	4
DP1.3	Understands the basic Ethno-STEM concept	2
DP1.4	Understands full local culture–STEM integration	0
DP2.1	Able to select locally relevant chemistry topics	8
DP2.2	Able to determine integration strategies	10
DP2.3	Able to use local resources	8
DP2.4	Able to prepare written learning materials	2
DP3.1	States readiness to implement Ethno-STEM	7
DP3.2	Needs further training	3
DP3.3	Reports high self-efficacy	4
DP3.4	States not yet ready to implement	2

To provide a clearer visualization of the distribution of teachers' pedagogical readiness categories, the frequency of coded themes across the three dimensions is presented in Figure 1.

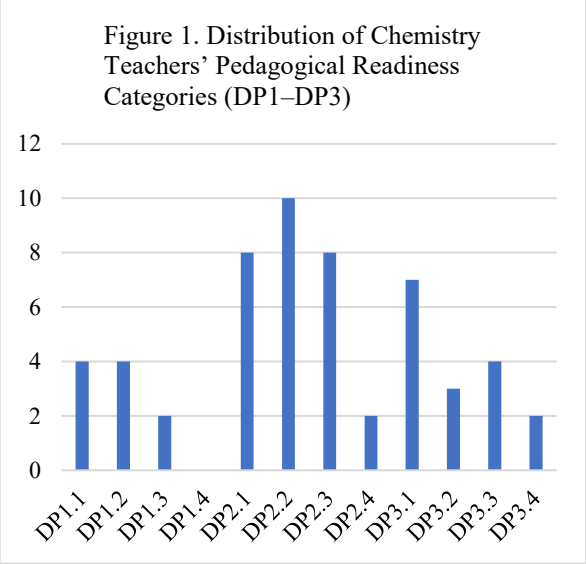


Figure 1. Distribution of Chemistry Teachers' Pedagogical Readiness Categories (DP1–DP3)

Understanding of Ethno-STEM

Teachers' understanding of Ethno-STEM remained at different levels. Most participants were categorized as DP1.1 (unfamiliar with Ethno-STEM) or DP1.2 (familiar with STEM but not yet with Ethno-STEM). Several teachers stated that they had only recently heard the term Ethno-STEM, while others understood STEM as an integrated approach to problem solving but had not yet understood how local culture or ethnoscience could be integrated systematically. No participant was categorized as DP1.4, indicating that comprehensive understanding of local culture STEM integration had not yet been demonstrated.

This pattern may suggest a theoretical-applied gap in teachers' understanding. Familiarity with STEM does not automatically provide the knowledge needed to integrate local cultural knowledge into

chemistry instruction. The finding is consistent with (Sulaeman et al., 2022; Talib et al., 2024), who reported that teachers may possess general STEM knowledge while still requiring professional development to design and implement STEM learning operationally. Similar concerns regarding teacher understanding of ethnoscience have been reported by Festiyed et al. (2022) and Marpaung et al., (2025). In the context of Ethno-STEM, the additional requirement is the ability to identify cultural phenomena that can be translated into scientifically valid chemistry learning contexts.

Ability to Design Ethno-STEM Learning

The second dimension concerns teachers' ability to transform contextual ideas into learning designs. Teachers demonstrated relatively strong contextual awareness: eight participants were able to select locally relevant chemistry topics, ten were able to determine integration strategies, and eight were able to identify or use local resources. However, only two participants were categorized as able to prepare written learning materials (DP2.4). This contrast shows that teachers can recognize opportunities for contextualization more readily than they can formalize those opportunities into systematic instructional documents.

The finding suggests that pedagogical readiness should not be judged solely from teachers' ability to identify local resources. Effective Ethno-STEM implementation requires teachers to translate those resources into learning objectives, activities, student tasks, assessment, and chemistry concepts. The low DP2.4 result therefore represents an important operational limitation. It also supports Rahmawan et al. (2023), who reported that readiness to prepare lesson plans, teaching materials, and assessment instruments for ethnoscience-oriented chemistry learning remains limited. Izzania and Sumarni (2024) similarly emphasized the importance of developing structured Ethno-STEM learning resources, while Kamaludin et al., (2024) and Hidayati and Julianto, (2025) demonstrate the value of contextual ethnoscience approaches in chemistry and science learning.

Professional Readiness

Professional readiness showed a more positive pattern. Seven teachers stated that they were ready to implement Ethno-STEM (DP3.1), four demonstrated high self-efficacy (DP3.3), three explicitly needed further training (DP3.2), and two stated that they were not yet ready (DP3.4). These findings suggest conditional optimism: teachers show willingness and confidence to try an innovative approach, but their readiness remains constrained by incomplete conceptual understanding and limited experience in producing systematic instructional designs. This pattern is consistent with teacher-readiness findings reported by Sulaeman et al., (2022), Ekayanti et al., (2025), and Syofyan et al., (2024).

The combination of positive orientation and remaining competence gaps is important for understanding teacher readiness. A teacher may be willing to implement Ethno-STEM without yet possessing the operational competence required to design it. Thus, professional readiness in this study is better understood as transitional rather than fully established. This interpretation is consistent with research showing that teacher readiness for STEM education is influenced by knowledge, experience, self-efficacy, and opportunities for professional development (Sulaeman et al., 2022; Talib et al., 2024).

Supporting Role of Teachers' Positive Perceptions

Although perception was not treated as a separate variable in this article, teachers' positive perceptions provide supporting evidence for their pedagogical readiness. Teachers generally viewed the integration of local culture into science as important, believed that Ethno-STEM could increase students' motivation and engagement, and considered the approach applicable through creative use of digital devices and the local

environment. These perceptions are consistent with findings that teachers' attitudes influence STEM instructional practices (Thibaut et al., 2018; Margot & Kettler, 2019) and that local wisdom can make science learning more meaningful and culturally relevant (Ihsan et al., 2024; Atmojo et al., 2025).

At the same time, the positive orientation did not automatically correspond to full operational readiness. The central finding of this study is therefore the gap between teachers' willingness to adopt Ethno-STEM and their capacity to translate contextual ideas into systematic learning plans. This distinction identifies professional development as a bridge between affective readiness and practical implementation.

Implications

The findings imply that professional development for chemistry teachers should move beyond introducing the concept of Ethno-STEM. Training should provide practical opportunities to identify local cultural phenomena, map them onto relevant chemistry concepts, develop learning activities, prepare teaching materials, and design assessments. This recommendation is consistent with evidence that professional development and school support are important for teachers' implementation of integrated STEM (Ekayanti et al., 2025; Darif et al., 2024; Alagoz and Canli, 2024).

Practical Implications

The findings have direct implications for the design of teacher professional development in chemistry education. Because the main difficulty was not teachers' rejection of Ethno-STEM but the limited ability to translate contextual ideas into systematic instructional designs, training should be organized around concrete design tasks rather than conceptual exposition alone. Teachers can be guided to identify a local cultural practice, reconstruct its relevant scientific meaning, map the phenomenon to chemistry concepts, formulate learning objectives, design student activities, and prepare assessment instruments. Such a sequence would directly address the gap identified between teachers' contextual awareness and their ability to prepare written learning materials. This emphasis is also consistent with research on chemistry teachers' pedagogical and technological knowledge and the need for integrated instructional competence (Sutiani et al., 2022; Sulaeman et al., 2022).

At the school level, professional development should be accompanied by institutional support. Schools can facilitate collaborative planning among chemistry teachers and other subject teachers, provide access to local-resource databases or teaching-material repositories, and allocate opportunities for teachers to share and revise contextual lesson designs. The findings from JIPK studies on ethnopedagogy and local-wisdom-based chemistry resources indicate that culturally grounded learning requires instructional materials that are sufficiently structured for classroom use (Siswanto et al., 2025; Purba et al., 2024; Sutiani et al., 2022; Silaban et al., 2025). Therefore, school support should not be limited to general training but should include time, collaboration, and access to usable learning resources.

For chemistry education more broadly, the study suggests that Ethno-STEM implementation should be viewed as a process of gradual capacity building. Teachers may begin with locally relevant chemistry topics and simple contextual activities before progressing toward more complex STEM integration involving design, technology, and problem solving. The development of STEM-integrated chemistry resources also shows that structured materials can help translate an integrated approach into concrete learning

experiences (Ibrahim & Sutiani, 2025). In this sense, pedagogical readiness is not a fixed status but a developmental pathway that can be strengthened through repeated practice, feedback, collaboration, and contextual professional learning.

Limitations

This study is limited to chemistry teachers in public senior high schools in Gorontalo and is based primarily on interview and documentation data. Classroom observations were not used to directly verify whether teachers' stated readiness corresponded to actual Ethno-STEM implementation. Future studies should therefore combine teacher-readiness analysis with classroom observation and should develop and test practical Ethno-STEM teaching tools that support teachers in translating local cultural knowledge into systematic chemistry instruction.

CONCLUSION

The study concludes that chemistry teachers in Gorontalo demonstrate conditional pedagogical readiness to implement Ethno-STEM learning. Teachers generally possess positive contextual awareness, willingness, and confidence toward integrating local culture into chemistry learning. However, their understanding of the integrated Ethno-STEM framework remains uneven, and their ability to translate contextual ideas into systematic written learning designs is still limited. The strongest readiness was observed in teachers' ability to identify relevant topics, integration strategies, and local resources, whereas the weakest aspect was the preparation of written instructional materials. These findings indicate that the central issue is not teachers' rejection of Ethno-STEM, but the gap between positive orientation and operational pedagogical competence. Professional development should therefore provide practical support for mapping local cultural phenomena to chemistry concepts, designing learning activities, preparing instructional materials, and developing appropriate assessments.

ACKNOWLEDGEMENT

The authors express their gratitude to the Chemistry Education Study Program, Postgraduate Program, Universitas Negeri Gorontalo, and to the participating school leaders and chemistry teachers who provided access and contributed their experiences to this study.

REFERENCE

Alagoz, T., & Canli, S. (2024). The Effect of Innovative Schools and Schools' Openness to Change on Teachers' Adaptive Performance. *Journal Of Theoretical Educational Science*, *17*, 791–813. https://doi.org/10.30831/akukeg.1466406

Aslam, S., Alghamdi, A. A., & Abid, N. (2023). Challenges in Implementing STEM Education : Insights from Novice STEM Teachers in Developing Countries. *Journal Sustainability*, *15*(19). https://doi.org/10.3390/su151914455

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*, *9*(3), 79–86. https://doi.org/10.15294/jise.v9i2.38505

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*. *14*(2), 251–266. https://doi.org/10.15294/jpii.v14i2.23505

Carter, N., Bryant-lukosius, D., Dicenso, A., & Blythe, J. (2014). The Use of Triangulation in Qualitative Research. *Oncology Nursing Forum*, *41*(5), 2014.

https://doi.org/10.1188/14.ONF.545-547

Creswell, J. W. (2017). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*. SAGE Publications. https://books.google.co.id/books?id=335ZDwAAQBAJ

Dali, K., & Yunus, R. (2025). Representation of Huyula Local Wisdom Values as Character Strengthening for Elementary School Students. *Journal Of Basic Education Research*, *6*(2), 288–295. https://doi.org/10.37251/jber.v6i2.1826

Darif, M., Yuhana, Y., Sultan, U., & Tirtayasa, A. (2024). *Implementasi Supervisi Kolaboratif Dalam Peningkatan Kompetensi Profesional Guru*. *22*(16), 163–176. https://doi.org/10.31571/edukasi.v21i1.7511

Ekayanti, N. W., Suastra, I. W., & Suma, K. (2025). *INTERNATIONAL CONFERENCE PROCEEDINGS Teacher Readiness in STEM – Deep Learning : A Cluster-Based Approach to Tiered Professional Development*. *1*, 769–793.

Emil, Lincoln, Y. S., Guba, E. G., & Inquiry, N. (1985). *Naturalistic Inquiry*. https://doi.org/10.1016/0147-1767(85)90062-8

Festiyed, Elvianasti, M., Diliarosta, S., & Anggana, P. (2022). Pemahaman Guru Biologi SMA di Sekolah Penggerak DKI Jakarta terhadap Pendekatan Etnosains pada Kurikulum Merdeka. *Jurnal Pendidikan Dan Kebudayaan*, *7*(22), 8–11. https://doi.org/10.24832/jpnk.v7i2.2993

Hidayati, F., & Julianto. (2025). Integrasi Pendekatan Etnosains dalam Pembelajaran Sains untuk Meningkatkan Keterampilan Berpikir Kritis Siswa. *JURNAL PEMIKIRAN PENDIDIKAN*, *31*(1), 101–112. https://doi.org/10.30587/didaktika.v31i1.9578

Ibrahim, T. A., & Sutiani, A. (2025). Development of a Chemistry E-module with a STEM-Integrated Project Based Learning Model on Chemical Equilibrium Material. *Jurnal Inovasi Pembelajaran Kimia*, *7*(2), 226–234. https://doi.org/10.24114/jipk.v7i2.69594

Ihsan, M., Lukum, A., & Jusuf, M. I. (2024). Desain Kearifan Lokal Gorontalo sebagai Bahan Kajian dalam Pembelajaran Sains. *Jambura Journal of Educational Chemistry*, *6*. https://doi.org/https://doi.org/10.37905/jjec.v6i1.23506

Izzania, R. A., & Sumarni, W. (2024). Jurnal Inovasi Pendidikan Kimia Pengembangan E-Modul Ajar Kimia Hijau Bermuatan Etno-STEM Berbasis Guided Inquiry untuk Membekali Kemampuan Berpikir Kritis Peserta Didik. *Jurnal Inovasi Pendidikan Kimia Http://Journal.Unnes.Ac.Id/Nju/Index.Php/JIPK*, *18*(1). https://doi.org/https://doi.org/10.15294/jipk.v18i1.46536

Kamaludin, A., Sriyani, S., & Liliawati, W. (2024). *Study of the Ethnoscience Learning Approach About the Keris Yogyakarta for Chemistry Learning in High School*. *6*(1), 17–26. https://doi.org/10.21580/jec.2024.6.1.20961

Kelley, T. R., & Knowles, J. G. (2016). A Conceptual Framework for Integrated STEM Education. *International Journal of STEM Education*, *3*(11), 1–11. https://doi.org/10.1186/s40594-016-0046-z

Khoiriyah, N., Sumarti, S. S., & Harjono, A. (2025). Development of Ethno-STEM-based teaching materials:

Validity and contextual implementation. *International Journal of Instruction*, *18*(1), 321–336. https://doi.org/10.29333/iji.2025.18123a

Listiyani, L. R., Wilujeng, I., Suyanto, S., & Pratama, H. (2025). EthnoSTEM-based Learning Tools : Connecting Cultural Heritage with STEM Education. *International Electronic Journal of Elementary Education*, *17*(4), 593–609. https://doi.org/10.26822/iejee.2025.402

Margot, K. C., & Kettler, T. (2019). Teachers' Perception of STEM Integration and Education: A Systematic Literature Review. *International Journal of STEM Education*, *6*(2), 1–16. https://doi.org/10.1186/s40594-018-0151-2

Marpaung, D. N., Retnawati, H., & Arianingrum, R. (2025). Teacher's Understanding Of Ethnoscience-Based Chemistry Learning In Papua. *QUANTUM: Jurnal Inovasi Pendidikan Sains*, *16*(1), 1–8. https://doi.org/: http://dx.doi.org/10.20527/quantum.v16i1

Masayu, R. A. (2024). Analisis penerapan pendekatan etnosains dalam pembelajaran kimia untuk meningkatkan literasi sains sisw. *Jurnal Riset Pendidikan Kimia*, *14*(2), 144–149. https://doi.org/https://doi.org/10.21009/JRPK.142.09

Menganti, S. A. (2023). Kompetensi Pedagogik Guru Dalam Pelaksanaan Kurikulum Merdeka. *Jurnal Review Pendidikan Dasar: Jurnal Kajian Pendidikan Dan Hasil Penelitian*, *9*(3). https://doi.org/https://doi.org/10.26740/jrpd.v9n3.p153-160

Miles, M. B., & Huberman, A. M. (1994). *Qualitative Data Analysis: An Expanded Sourcebook (2nd ed.)*.

Mohi, S. (2021). Eksistensi Budaya Lokal Gorontalo Sebagai Identitas Suku Bangsa Dalam Dimensi Globalisasi Dan Modernisme. *Jurnal Kepemimpinan & Pendidikan Islam*, *5*, 56–75. https://doi.org/https://doi.org/10.47945/transformasi.v5i1.504

Panggabean, F. T. M., Silitonga, P. M., Sutiani, A., Purba, J., & Gultom, R. (2023). Inquiry Based Learning STEM Teaching Materials to Improve Students ' Thinking Skills in Stoichiometry. *JTK: Jurnal Tadris Kimiya*, *2*, 157–164.

Purba, L. S. L., Tamansa, S. A., Peronika, R. Y., Simaoju, A. S., & Harefa, I. J. (2024). Analysis of The Need for Chemical Learning Media Based on Local Wisdom in Sitaro Islands. *Jurnal Inovasi Pembelajaran Kimia*, *6*(1), 68–76. https://doi.org/10.24114/jipk.v6i1.57355

Rahmawan, S., Rahayu, D. S., Kimia, P., Tidar, U., & Magelang, K. (2023). *Bibliometric Methods: Analysis of the DevelopmentPotential of Ethnoscience-based Science Literacy Modules in ChemistryLearning*. *07*(2). https://doi.org/10.31002/ijose.v7i2.1104

Sanova, A., Bakar, A., Kimia, P. P., & Jambi, U. (2021). Pendekatan Etnosains Melalui Model Problem Based Learning Terhadap Kemampuan Literasi Kimia Materi Larutan Penyangga The Use Of Ethnoscience Approach Through Problem Based Learning. *Jurnal Zarah*, *9*(2), 105–110. https://doi.org/https://doi.org/10.31629/zarah.v9i2.3814

Sihombing, R. A., Anwar, S., Liu, S., & Winarno, N. (2025). *Integrating Local Wisdom into Environmental Education : A Systematic Review of*

Ethnoscience Research in Indonesia. *8*(1), 57–74. https://doi.org/10.24014/jnsi.v8i1.35762

Silaban, R., Hutasoit, G. O., Soripada, T. A., Sitorus, M., Duma Riris, I., Almira Samosir, R., & Afifah Daulay, R. (2025). Influence of Ethnopedagogical Materials and Problem Based Learning on Students Learning Interest and Critical Thinking. *Jurnal Inovasi Pembelajaran Kimia*, *7*(1). https://doi.org/10.24114/jipk.v7i1.67607

Siswanto, S., Tasya, A., Tarigan, S., & Silaban, R. (2025). *Needs Analysis of Innovative Chemistry Teaching Materials Integrated with Ethnopedagogy Oriented to 21st Century Learning*. 214–225. https://doi.org/10.24114/jipk.v7i2.68601

Sodikin, H. (2022). The Management of Pedagogical Competence Development as an Effort to Improve The Quality of PAI Learning Process Manajemen Pengembangan Kompetensi Pedagogik Guru dalam Upaya Meningkatkan Mutu Proses Pembelajaran PAI Universitas Islam Nusantara. *The Journal of Educational Research*, *2*(2). https://doi.org/https://doi.org/10.57032/edukasi.v2i2.133

Sugiyono. (2022). *Metode Penelitian Kuantitatif, Kualitatif dan R&D* (Ed.2, Cet.). Alfabeta.

Sulaeman, N., Efwinda, S., Dwi, P., & Putra, A. (2022). Teacher Readiness In Stem Education: Voices Of Indonesian Physics Teachers. *Journal of Technology and Science Education*, *12*(1), 68–82. https://doi.org/https://doi.org/10.3926/jotse.1191

Sutiani, A., Muchtar, Z., Dibyantini, R. E., Sinaga, M., & Purba, J. (2022). *Analisis Kemampuan Guru-Guru Kimia SMA Sumatera Utara Dalam Mengintegrasikan TPACK*. *4*(2). https://doi.org/10.24114/jipk.v4i2.39259

Syofyan, H., Rosyid, A., Fadli, M. R., & Yusuff, A. A. (2024). *Teacher Readiness Factors that Influence the Implementation of the Merdeka Curriculum in Elementary Schools*. *13*(5), 168–180. https://doi.org/10.5430/jct.v13n5p168

Talib, S., Alias, B. S., Effendi, M., & Mohd, E. (2024). Exploring Teacher Preparedness for STEM Education : A Systematic Literature Review. *Journal of Educational Research*, *12*(6), 136–146. https://doi.org/10.13189/ujer.2024.120602

Thibaut, L., Knipprath, H., Dehaene, W., & Depaepe, F. (2018). Integrated STEM Education: A Systematic Review. *International Journal of STEM Education*, *5*(1), 1–18. https://doi.org/10.1186/s40594-018-0114-6

Wilujeng, I., & Ungirwalu, S. Y. (2024). *Analysis of Integrating Local Potential in Science Learning and its Effect on 21 st Century Skills and Student Cultural Awareness : Literature Review*. *10*(5), 223–233. https://doi.org/10.29303/jppipa.v10i5.6485

Yue, M., Siu, M., Jong, Y., Tsz, D., & Ng, K. (2024). Understanding K – 12 teachers ' technological pedagogical content knowledge readiness and attitudes toward artificial intelligence education. In *Education and Information Technologies* (Vol. 29, Issue 15). Springer US. https://doi.org/10.1007/s10639-024-12621-2