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Ethno-STEM Integration and Differentiated Learning for SDG 4 Quality Education: A Bibliometric Analysis and Systematic Review

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Abstract: This study examines the integration of Ethno-STEM with differentiated learning through bibliometric analysis (15 Scopus documents, 2015–2024) and systematic literature review (15 articles, 2015–2024). Bibliometric results reveal a focused research landscape dominated by United States institutions, with steady publication growth post-2020. SLR synthesis identifies key pedagogical themes, including culturally responsive pedagogy, personalized learning, and the necessity of culturally adaptive teaching. The integration of these approaches fosters inclusive, student-centered environments that value local wisdom. However, challenges persist in teachers' culturally responsive STEM literacy and the design of diverse learning products. This research contributes to the development of the Differentiated Ethno-STEM Knowledge (DESK) framework, providing a systematic roadmap for teacher professional development. Conclusively, these findings offer actionable insights for sustainable education policy, directly advancing Sustainable Development Goal 4 (Quality Education) through contextually relevant and inclusive 21st-century learning strategies.

Keywords: Bibliometric analysis; Culturally responsive teaching; DESK framework; Differentiated learning; Ethno-STEM; SDG 4

Introduction

Twenty-first century education demands pedagogical strategies that are both adaptive to learner diversity and deeply rooted in cultural contexts (Adeoye et al., 2024; Dishon & Gilead, 2020; García-Peñalvo, 2021). Differentiated learning has emerged as a critical approach to address heterogeneity in students' readiness, interests, and learning profiles by systematically modifying content, processes, and assessment products (Tomlinson & Imbeau, 2023; Valiandes & Neophytou, 2018). When implemented effectively, differentiation ensures equitable access to high-quality education, enabling all learners to reach their maximum potential regardless of their initial abilities (Dishon & Gilead, 2020; Pozas et al., 2020). However, differentiation alone often lacks contextual relevance, particularly in STEM education, where abstract concepts may feel disconnected from student's lived experiences (Huda, 2024; Marlina et al., 2024).

To bridge this gap, the Ethno-STEM (Ethnoscience–Science, Technology, Engineering, and Mathematics) approach has gained prominence by systematically embedding local wisdom and indigenous knowledge into STEM curricula (Ariani & Hariyadi, 2024; Zidny et al., 2020). Ethno-STEM transforms abstract scientific principles into culturally meaningful learning experiences, fostering deeper student engagement while enhancing STEM literacy and creative problem-solving skills (Anggraini et al., 2025; Babalola & Keku, 2024; Qurniati & Wahyudiati, 2023; Sani et al., 2024). By contextualizing instruction within familiar cultural

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practices, ethnoscience-based modules have demonstrated significant potential in improving both science literacy and higher-order thinking among secondary students (Afriana et al., 2016; Prabawati et al., 2023; Astuti et al., 2021; Atmojo et al., 2025; Jihannita et al., 2024; Juliantara et al., 2024; Sudirman et al., 2025; Wardani et al., 2021). Recent pedagogical innovations further validate that aligning STEM content with local cultural characteristics not only makes learning more relevant but also strengthens learners' adaptive and creative capacities (Nurkhasyanah et al., 2025; Setiawan & Sudarmin, 2023). Consequently, the synergistic integration of differentiated learning and Ethno-STEM represents a highly promising pedagogical model for 21st-century classrooms, effectively aligning instructional design with both learner diversity and cultural sustainability.

The synergistic integration of differentiated learning and Ethno-STEM represents an optimal strategy for contemporary education, reflecting 21st-century pedagogical abilities to design learning adaptive to learner diversity while linking materials to local wisdom (Ardianti et al., 2023; Wardani et al., 2023). However, despite widespread recognition of this approach, implementation remains constrained. While previous literature has extensively documented structural challenges—such as high workloads, crowded curricula, and limited institutional support (Maphumulo & Biccard, 2024; Rosadi et al., 2024)—this study identifies a more critical pedagogical barrier: teacher's limited structured knowledge in simultaneously applying differentiation strategies, Ethno-STEM content, and culturally responsive assessment. Consequently, the core impediment lies not merely in structural constraints, but in the absence of a systematic competency framework that guides educators in merging cultural contextualization with differentiated pedagogy. Without explicit knowledge domains, educators struggle to design inclusive, culturally relevant STEM products that accommodate diverse learning pathways. This study addresses that gap by shifting the focus from structural constraints to pedagogical knowledge development, thereby offering a targeted solution for teacher capacity building.

The novelty of this research lies in its dual-method approach that first maps the global evolution of differentiated learning research and then identifies the precise pedagogical knowledge domains required for Ethno-STEM integration. By combining bibliometric analysis with a systematic literature review, this study moves beyond fragmented discussions to construct a comprehensive Differentiated Ethno-STEM Knowledge (DESK) framework. This research is critically important as it provides evidence-based guidance for teacher professional development, directly supporting Sustainable Development Goal 4 (Quality Education) through culturally responsive and inclusive pedagogy. Accordingly, this study aims to map the global research trajectory of differentiated learning, synthesize the essential knowledge domains for Ethno-STEM differentiation through systematic literature review, and develop the DESK framework as a conceptual model to enhance teacher competencies in 21st-century STEM education.

Method

Research Design

This study employs a mixed-methods design combining bibliometric mapping with a systematic literature review (SLR) to comprehensively analyze the integration of Ethno-STEM and differentiated learning. The bibliometric phase provides a macroscopic overview of global research trends, while the SLR phase offers a microscopic synthesis of pedagogical knowledge domains, culminating in the development of the Differentiated Ethno-STEM Knowledge (DESK) framework.

Bibliometric Analysis Protocol

Data were retrieved exclusively from the Scopus database to ensure standardization and high-quality indexing. The search strategy utilized a refined Boolean string to align precisely with the research focus: TITLE-ABS-KEY (("differentiated learning" OR "differentiated instruction" OR "adaptive teaching" OR "personalized learning") AND ("Ethno-STEM" OR "ethnoscience" OR "local wisdom" OR "culturally responsive" OR "indigenous knowledge")). The publication timeframe was standardized to January 2015–December 2024. The initial search yielded 15 documents, which underwent rigorous screening. After applying inclusion filters (English language, peer-reviewed journals, education/STEM-related subject areas, excluding clinical medicine), all 15 documents were retained for network visualization using VOSviewer (version 1.6.19) and bibliometric analysis following (Donthu et al., 2021; Eck & Waltman, 2010).

Systematic Literature Review Protocol

The SLR phase targeted empirical and theoretical studies that explicitly explore the intersection of differentiation and cultural contextualization in STEM education. Literature was systematically searched across Scopus, ScienceDirect, SAGE Journals, Taylor & Francis, and Google Scholar using the same 2015–2024 timeframe. The selection process adhered to the PRISMA 2020 guidelines (Page et al., 2021). Strict inclusion criteria were applied: peer-reviewed journal articles with full-text availability; explicitly integrating

differentiated instruction and local wisdom in K-12 or teacher education contexts; published between 2015 and 2024; and focus on pedagogical or competency development. Articles were excluded if they focused solely on theoretical mathematics without STEM integration, lacked empirical implications, or were published in non-academic outlets. Following deduplication and full-text screening, 15 articles were selected for in-depth thematic synthesis. Data were analysed using thematic analysis (Braun & Clarke, 2006; Thomas & Harden, 2008).

Validity and Reliability

Quality assurance was maintained through transparent documentation of search protocols, comprehensive methodological reporting, and iterative peer verification. Database triangulation was specifically implemented during the SLR phase across multiple academic platforms to minimize database-specific bias, whereas bibliometric mapping relied solely on Scopus to preserve analytical consistency. Thematic coding was conducted independently by two researchers, with inter-coder discrepancies resolved through consensus discussion. All screening, coding, and synthesis procedures were meticulously documented to ensure replicability.

Result and Discussion

Bibliometric Landscape of Differentiated Learning Research

To map the global research landscape of differentiated learning, bibliometric analysis was conducted on the Scopus database for the period 2015–2024. The document search and selection process followed a systematic protocol to ensure data quality and relevance.

As shown in Figure 1, the refined search strategy yielded 15 documents that explicitly addressed the integration of differentiated learning with Ethno-STEM or culturally responsive approaches. This focused dataset reflects the emerging yet highly specialized nature of research explicitly integrating these pedagogical dimensions. Analysis reveals significant publication growth post-2020, with peak output in 2024. The period 2020–2024 marked increased urgency for personalized learning in response to learner diversity and educational disruptions (Pozas et al., 2020; Tomlinson & Imbeau, 2023). The highly focused yield of 15 documents underscores the nascent but rapidly consolidating nature of Ethno-STEM differentiated learning research, directly validating the need for structured competency frameworks like DESK to guide systematic implementation. This scarcity of integrated literature implies that teacher professional development must currently rely on deliberate, cross-disciplinary synthesis rather than established curricular models.

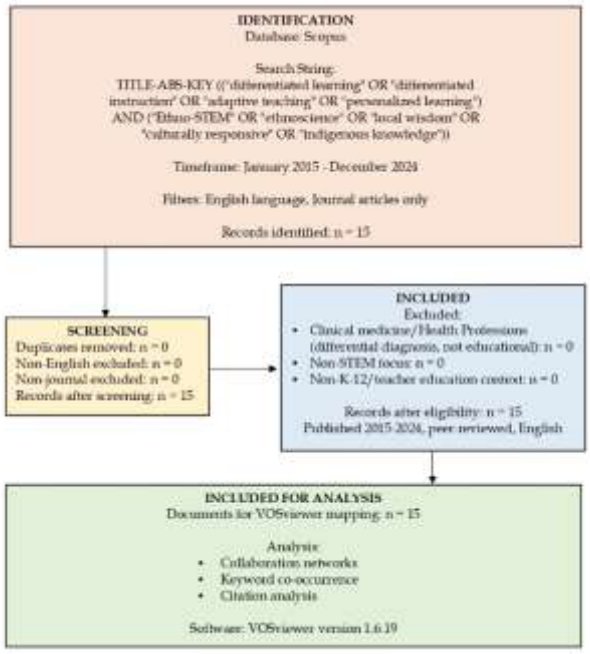

Figure 1. Bibliometric search flow chart illustrating identification, screening, eligibility, and inclusion of Scopus documents (2015–2024)

As illustrated in Figure 2, the temporal distribution reveals a remarkable acceleration in research output, culminating in 5 documents in 2024 alone. This growth pattern aligns with global educational transformations that necessitated adaptive and personalized learning solutions. The exponential publication growth post-2020, peaking in 2024, mirrors the global educational pivot toward adaptive, culturally grounded pedagogy following pandemic-induced disruptions. This temporal surge highlights a critical implementation window, urging educational policymakers to institutionalize Ethno-STEM differentiation strategies before the field fragments into isolated pedagogical silos.

Figure 3 reveals the intellectual structure of the field through keyword co-occurrence patterns. The network displays distinct thematic clusters: a red cluster centered on "indigenous knowledge" and "climate change," a blue cluster around "learning," "curriculum," and "pedagogy," and connections to "sustainability" and "local wisdom" that bridge multiple clusters. This distribution demonstrates the interdisciplinary nature of the research, spanning environmental science, education, cultural studies, and sustainable development. The co-occurrence network reveals a strong interdisciplinary bridge between "local wisdom" and "curriculum/pedagogy," empirically validating the DESK framework's foundational premise that cultural context must be structurally integrated into STEM

instruction rather than treated as supplementary content. This thematic convergence guides curriculum developers toward designing modular, culturally anchored STEM units that inherently support differentiated learning pathways.

Figure 4 presents author keyword co-occurrence, revealing more specific research specializations. The prominent positioning of "indigenous knowledge" and "local wisdom" at the network center indicates these are core conceptual foundations. Surrounding clusters include climate adaptation, resilience, cultural heritage, and decolonization, suggesting that contemporary research increasingly addresses cultural preservation and epistemic justice in education. The prominence of "resilience," "decolonization," and "project-based learning" alongside traditional pedagogical terms reflects a paradigm shift toward culturally adaptive teaching, directly aligning with the DESK framework's highest competency tier: innovative learning creation. This evolution suggests that teacher professional development must incorporate decolonial pedagogies and technology-integrated project-based learning to foster both student agency and cultural resilience.

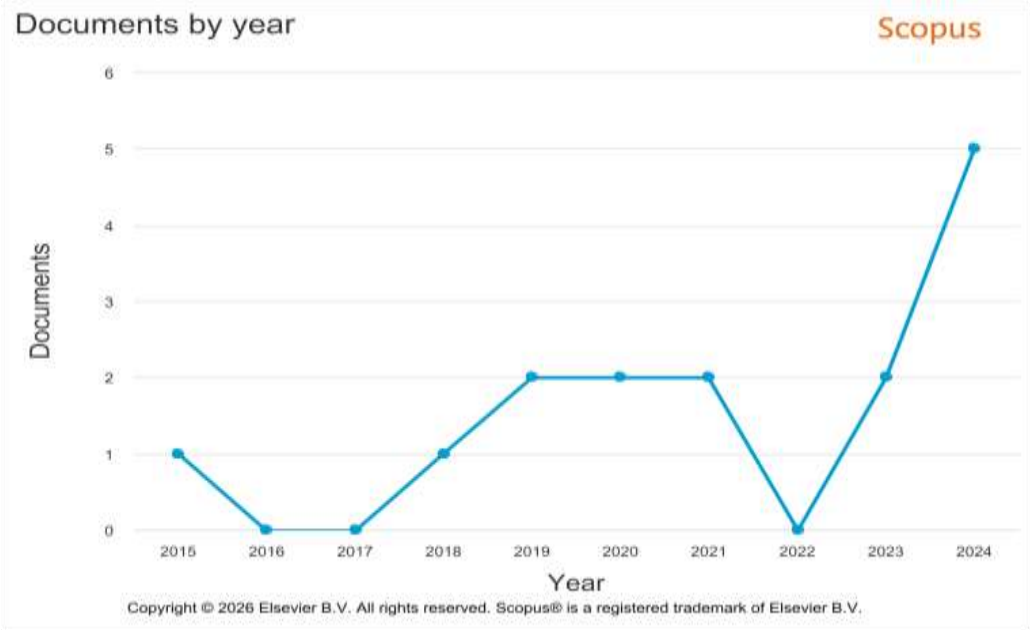

Figure 2. Temporal distribution of Ethno-STEM differentiated learning publications in Scopus database (2015–2024)

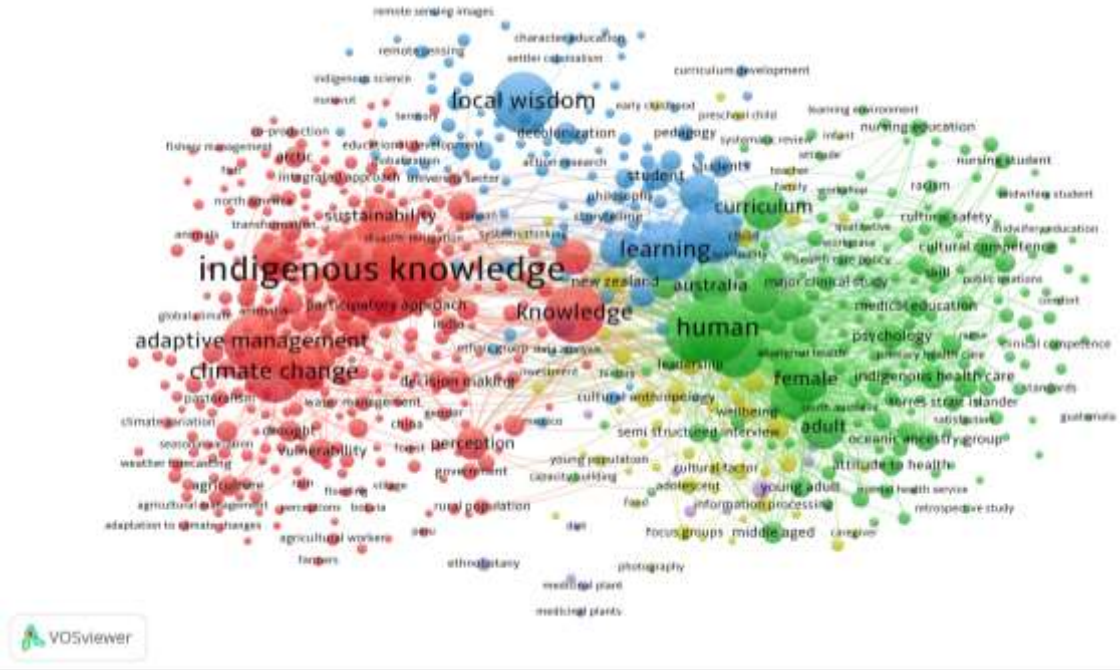

Figure 3. Co-occurrence network of all keywords in Ethno-STEM differentiated learning research (2015–2024)

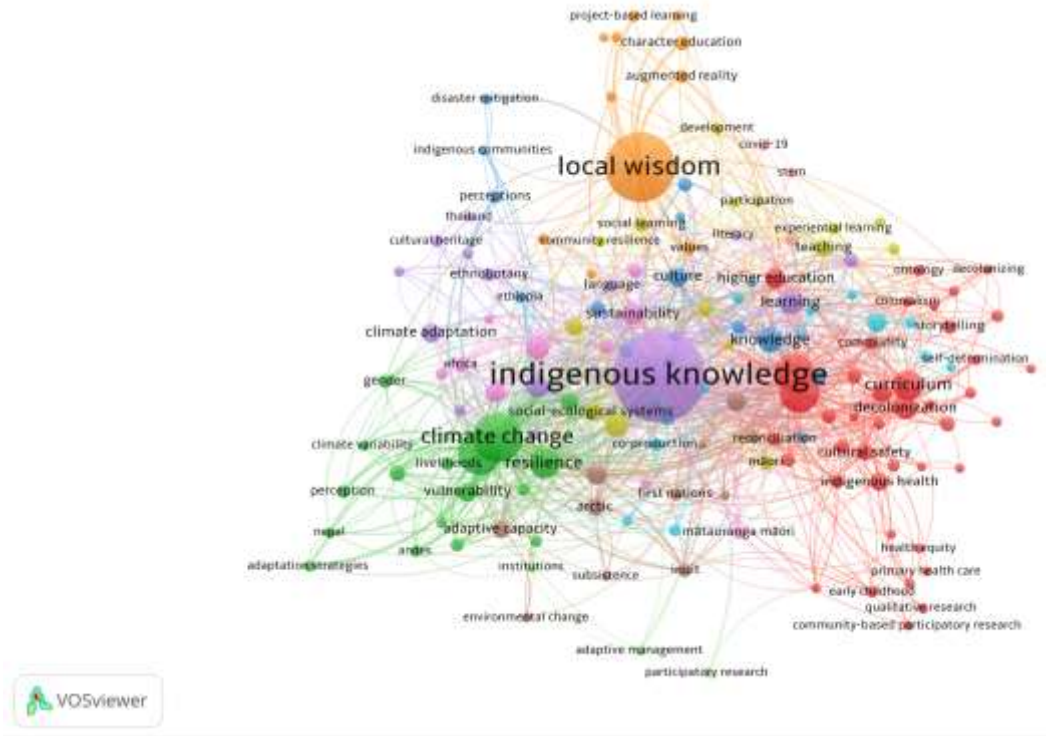

Figure 4. Co-occurrence network of author keywords showing specialized research foci (2015–2024)

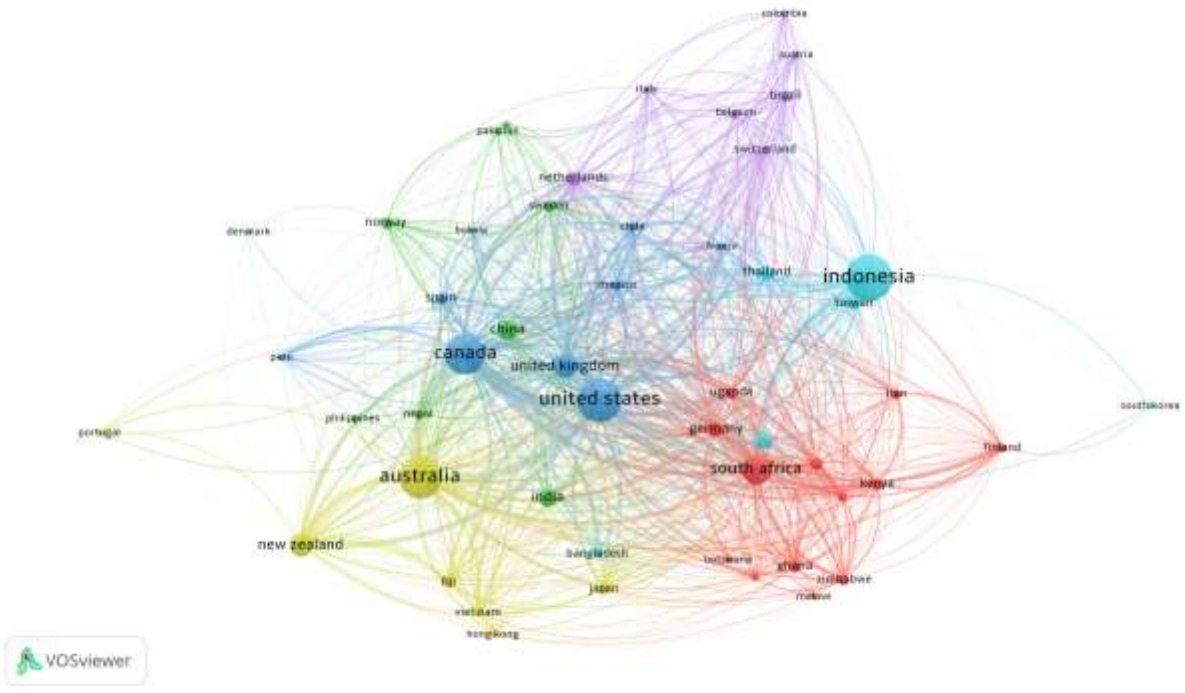

Figure 5. Bibliographic coupling network of countries showing collaborative relationships (2015–2024)

Figure 5 illustrates the global structure of research partnerships. The United States leads with 9 documents, followed by Canada, China, Cyprus, Indonesia, New Zealand, Peru, South Africa, and the United Kingdom (1 each). The dense interconnections between countries across continents demonstrate the universal relevance of differentiated pedagogical approaches and the global commitment to integrating local wisdom into STEM education. The geographic diversification, with emerging research nodes in Southeast Asia alongside established North American and European hubs, demonstrates the cross-cultural transferability of

differentiated Ethno-STEM pedagogy. This global distribution supports the universal applicability of the DESK framework while encouraging strategic academic partnerships to co-develop context-specific Ethno-STEM modules tailored to diverse educational ecosystems.

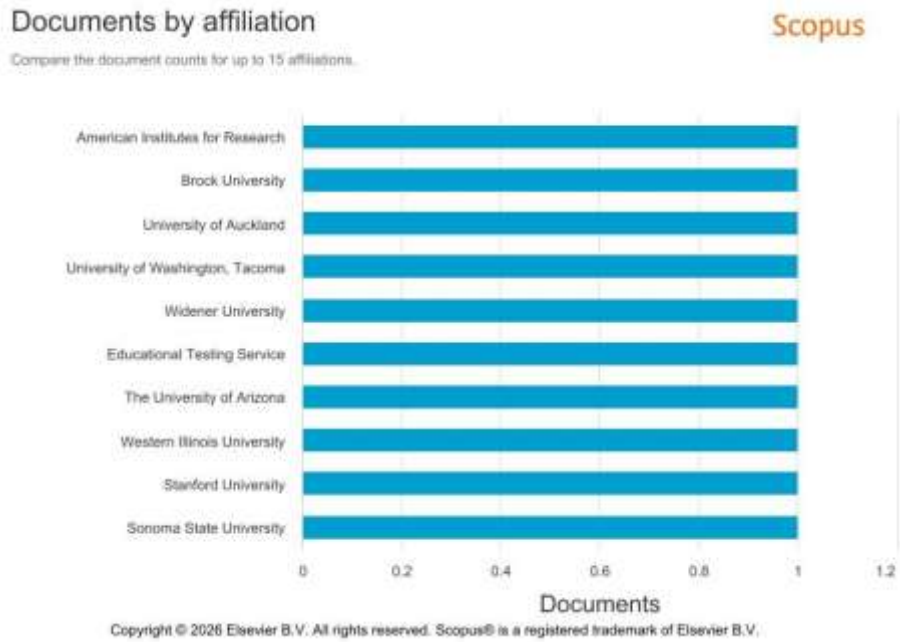

Figure 6. Distribution of publications by top institutions (2015–2024)

Institutional analysis shows a highly fragmented landscape, with publications scattered across 28 unique institutions (e.g., American Institutes for Research, Brock University, University of Auckland, Universitas Islam Malang), each contributing one document. This fragmentation suggests that the field is still emerging, without a single dominant centre of excellence, but rather a distributed network of scholars exploring cultural integration in differentiated instruction. The highly fragmented institutional landscape, with no single dominant research center, indicates that Ethno-STEM differentiation remains a decentralized, grassroots scholarly movement rather than an institutionalized pedagogical standard. This structural gap underscores the urgent need for national educational authorities to fund coordinated research networks and standardize Ethno-STEM differentiation competencies within pre-service teacher certification programs.

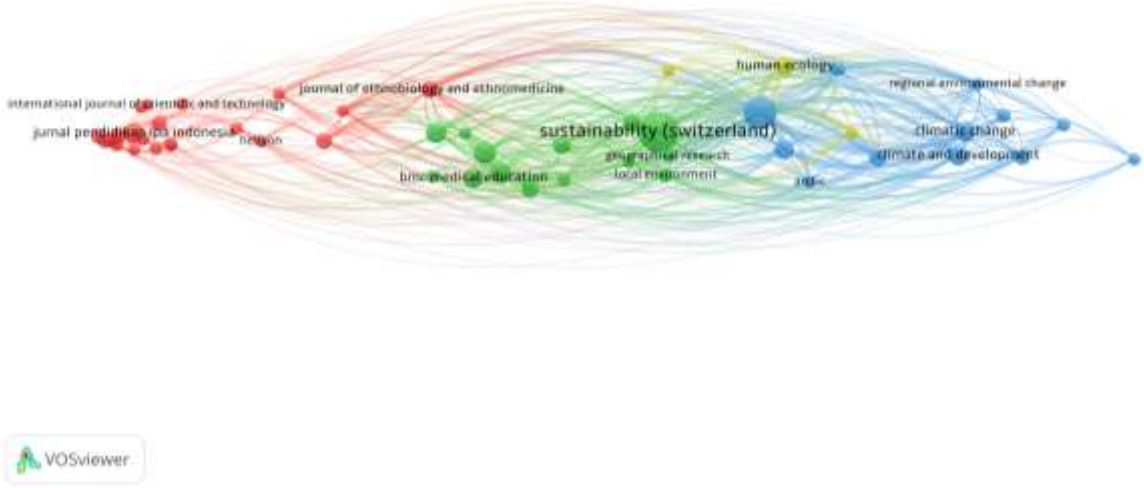

Figure 7. Bibliographic coupling network of sources showing publication venues (2015–2024)

Figure 7 reveals the publication ecosystem. Research is distributed across diverse venues spanning sustainability science, ethnobiology, medical education, and regional science education journals, reflecting its

interdisciplinary and globally distributed nature. Initial bibliometric queries often retrieve medical literature due to the clinical use of "differentiation"; these were systematically filtered to maintain pedagogical relevance. The central positioning of sustainability-focused journals alongside the emerging visibility of regional publications reflects the growing alignment between Ethno-STEM differentiation and SDG 4's equity objectives. This publication ecosystem signals to academic publishers and educational ministries the need to incentivize dedicated special issues and strengthen local journal indexing to amplify indigenous pedagogical research on a global scale.

Systematic Literature Review and DESK Framework Development

While bibliometric mapping establishes macro-level trends, specific pedagogical gaps were identified through the SLR phase. From 195 initial records, rigorous PRISMA screening yielded 15 articles that explicitly addressed the intersection of differentiation, cultural contextualization, and educational practice (Page et al., 2021).

As illustrated in Figure 8, 70 duplicates were removed during screening, leaving 125 records for title/abstract screening. Following full-text assessment, 110 articles were excluded due to wrong context (n = 30), lack of Ethno-STEM integration (n = 35), no differentiation focus (n = 25), non-peer-reviewed status (n = 10), or lack of empirical implications (n = 10). Ultimately, 15 articles met all criteria. The rigorous PRISMA filtration funneling 195 initial records down to 15 highly specific studies confirms the methodological precision required to isolate the intersection of differentiation and cultural contextualization, directly validating the evidence base for the DESK framework. This curated synthesis provides educational policymakers with a verified foundation for designing targeted, competency-based teacher training modules that bridge theoretical pedagogy with classroom-ready Ethno-STEM practices.

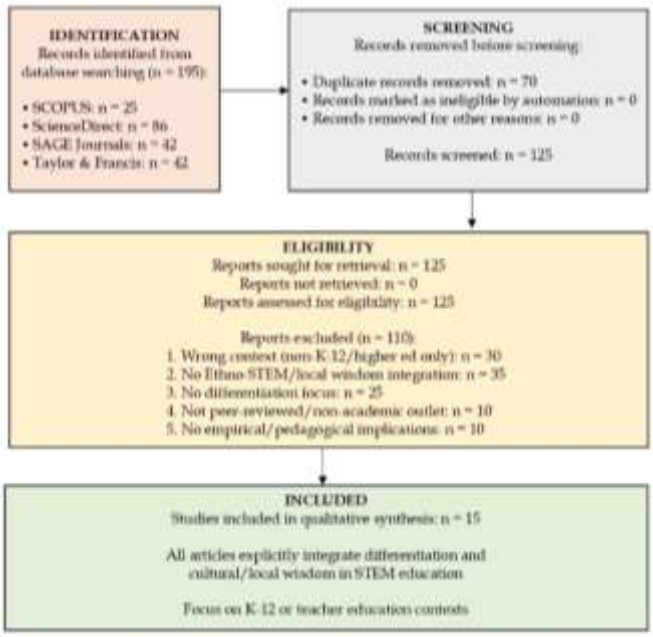

Figure 8. PRISMA 2020 flow diagram illustrating the systematic literature review selection process

Based on thematic analysis, this study identifies seven integrated knowledge domains essential for Ethno-STEM differentiated learning.

Table 1. Knowledge domains in the DESK framework

Domain	Description	Competency Indicators
Differentiation knowledge	Understanding how to identify and respond to learner diversity through content, process, and product modification	Able to identify learning styles, interests, and learner readiness levels
Local wisdom knowledge	Ability to identify, validate, and integrate indigenous cultural practices into educational contexts	Able to extract local wisdom values relevant to scientific and technological concepts
STEM content knowledge	Mastery of fundamental and advanced principles across science, technology, engineering, and mathematics disciplines	Able to accurately represent and sequence core STEM concepts for instruction
Technology-local wisdom knowledge	Understanding how digital tools can document, simulate, and amplify traditional knowledge systems	Able to integrate appropriate educational technology with culturally authentic materials
Differentiated STEM content knowledge	Ability to scaffold and adapt STEM materials to accommodate varying cognitive and cultural backgrounds	Able to modify content complexity and representation according to learner profiles
Local wisdom-differentiation knowledge	Knowledge of how cultural contexts naturally support varied pacing, grouping, and instructional strategies	Able to design culturally anchored activities that inherently accommodate diversity
Ethno-STEM differentiated learning knowledge	Synthesised ability to design, implement, and assess integrated learning that merges differentiation with Ethno-STEM	Able to develop, facilitate, and evaluate holistic, culturally responsive STEM

The DESK framework, structured across three competency levels, provides a systematic roadmap for teacher professional development.

Teacher Capacity and Implementation Challenges

Findings indicate that teachers' capacity to implement Ethno-STEM differentiated learning remains limited despite its recognised potential (Nurhasnah et al., 2022; Qurniati & Wahyudiati, 2023). Competency gaps are primarily identified in culturally responsive STEM literacy, creation of diverse learning products, and management of inclusive learning environments. Teachers demonstrate stronger abilities in adapting STEM content with local wisdom compared to designing differentiated assessment products or facilitating mixed-ability collaborative environments (Ardianti et al., 2023; Herayanti et al., 2025; Yulyanti et al., 2022). Furthermore, systematic reviews confirm that ethnoscience-based learning in elementary schools requires teachers to possess not only content mastery but also cultural mediation skills to effectively translate local practices into pedagogical resources (Ali et al., 2025). Structural barriers such as heavy workloads, rigid curriculum pacing, and limited access to culturally relevant instructional materials further constrain effective implementation (Burke & Lehane, 2023; Rosadi et al., 2024). These challenges highlight the need for targeted support systems that address both pedagogical knowledge and contextual constraints, particularly in resource-limited school settings. In multicultural classroom contexts, differentiation strategies must be deliberately adapted to accommodate linguistic diversity, varied cultural schemas, and heterogeneous prior knowledge, as evidenced by case studies in elementary settings (Sabir et al., 2024). This underscores that teacher capacity for Ethno-STEM differentiation is not merely technical but deeply contextual and relational.

Culturally Responsive and Adaptive Teaching Practices

Research demonstrates that culturally responsive pedagogy (CRP) provides a crucial framework for meeting the educational requirements of diverse student groups (Gay, 2018; Matiso, 2024). CRP emphasises the significance of acknowledging and merging students' background experiences into the learning environment to promote active participation that yields effective results (Alameddine, 2021). Empirical studies further show that teachers' indigenous knowledge and cultural competencies directly enhance student engagement and learning outcomes, particularly when educators intentionally bridge traditional epistemologies with formal curriculum objectives (Suarta et al., 2022). The framework acknowledges different cultural heritage of pupils as legacies that affect their learning and as valuable content within the curriculum, bridges the gap between home and school, deploys a variety of teaching and learning strategies, encourages pupils to embrace different cultures, and incorporates multicultural information across the curriculum (Hramia, 2015). Furthermore, evidence suggests that beginning teachers are capable of developing into "culturally adaptive teachers"—practitioners who continually adapt their pedagogy to better meet the needs of ethnically diverse pupils through ongoing reflection and cultural sensitivity (Hramia, 2015). Research indicates that intensive, practice-oriented training significantly enhances teachers' ability to design inclusive, culturally meaningful learning experiences (Wahyu et al., 2020). Furthermore, studies confirm that professional development programmes need not depend solely on teachers' indigenous cultural backgrounds; systematic instructional design training enables educators from any cultural origin to implement Ethno-STEM differentiation effectively (Ridwan et al., 2024; Zahro et al., 2024).

Technology Integration and Future Directions

The transformative impact of Artificial Intelligence (AI) on multicultural education shows potential to create personalised, inclusive, and culturally responsive learning environments (Mariyono & Akmal, 2024). AI technologies enable personalised learning experiences by adapting to individual student needs and providing real-time feedback, enhancing student engagement and learning outcomes. However, realizing this potential requires addressing ethical and practical challenges associated with AI deployment, including the digital divide, algorithmic bias, and ensuring equitable access to AI-driven educational resources. The adoption of a variety of instructional strategies, such as peer collaboration, technology-assisted learning, differentiated instruction, and interactive approaches, strengthens culturally responsive pedagogies in multicultural classrooms (Matiso, 2024). Emerging frameworks for culturally responsive personalized learning further emphasize the need for equitable technology integration that respects linguistic and cultural diversity while maintaining pedagogical integrity (Ober et al., 2023). Complementing these technological advances, pedagogical innovations such as the STEM-R (Reflective) approach have demonstrated efficacy in fostering students' reflective and critical thinking through structured inquiry cycles that integrate local phenomena with scientific reasoning (Sarwi et al., 2024).

Implications for Teacher Professional Development

The integration of differentiated learning and Ethno-STEM necessitates fundamental reconstruction of

teacher professional development programmes. Training must move beyond theoretical knowledge transfer to encompass practical skill development in designing, implementing, and evaluating culturally responsive, differentiated STEM instruction (Sani et al., 2024). This reconstruction aligns with broader curriculum reform agendas in Indonesia, where policy shifts toward local wisdom integration require teachers to develop new competencies in contextualising science education within culturally meaningful frameworks (Suprapto et al., 2021). The DESK framework offers a validated conceptual model to structure these programmes. Professional development programmes for differentiated instruction should emphasise both theoretical understanding and practical application in mixed-ability classrooms. Research demonstrates that well-designed development programmes can significantly impact teachers' professional learning and subsequently improve student achievement (Valiandes & Neophytou, 2018). Such programmes should incorporate ethnoscience content, differentiation strategies, technology integration, and culturally responsive teaching principles to prepare teachers for the complex demands of 21st century education (Ariska et al., 2023; Halawa et al., 2024).

Conclusion

This study synthesises the global research trajectory of differentiated learning and identifies the essential pedagogical knowledge domains required for effective Ethno-STEM integration. Following rigorous filtering of bibliometric data and systematic literature review, findings demonstrate that differentiated learning research has experienced steady growth post-2020, with strong collaborative networks anchored in North American, European, and emerging Asian institutions. Bibliometric mapping revealed a globally distributed but interconnected research community actively exploring the integration of indigenous knowledge, local wisdom, and differentiated pedagogy. The integration of differentiation strategies with culturally grounded STEM instruction presents a robust pedagogical model for fostering inclusive, contextually relevant education. However, implementation remains constrained by teacher's limited structured knowledge in merging cultural contextualisation with differentiated assessment and product design, as well as structural barriers such as heavy workloads and limited access to culturally relevant materials. To address these gaps, the Differentiated Ethno-STEM Knowledge (DESK) framework was developed, comprising seven interconnected competency domains that provide a systematic roadmap for teacher professional development. Furthermore, the synthesis highlights that culturally responsive and adaptive teaching practices, supported by equitable technology integration and targeted pedagogical training, are critical for overcoming implementation challenges. These findings offer foundational insights for restructuring teacher training programmes, curriculum design, and educational policy. While the global landscape is predominantly shaped by Western research ecosystems, the pedagogical principles identified hold strong potential for contextual adaptation within Indonesia's Merdeka Curriculum, provided that localized validation and implementation studies are conducted. Future research should prioritise experimental trials of the DESK framework in diverse school settings, longitudinal assessments of its impact on student STEM literacy, and the development of standardised instruments to measure culturally responsive differentiation competencies. Ultimately, advancing Ethno-STEM integration requires sustained investment in teacher knowledge development, collaborative community partnerships, and policy frameworks that validate indigenous knowledge as a core component of 21st-century science education, directly contributing to Sustainable Development Goal 4 (Quality Education).

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Author Contributions

Conceptualization, formal analysis, project administration, R. and H.A.; methodology, R., I.S., and H.A.; software, data curation, writing—original draft preparation, visualization, R.; validation, I.S., I., and E.; investigation, R., I.S., and I.; resources, H.A. and E.; writing—review and editing, I.S., I., H.A., and E.; supervision, I.S. and H.A. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

References

Adeoye, M. A., Prastikawati, E. F., & Abimbowo, Y. O. (2024). Empowering Learning: Pedagogical

Strategies for Advancing 21st Century Skills and Quality Education. *Journal of Nonformal Education*, *10*(1), 10–21. https://doi.org/10.15294/jone.v10i1.1451

Afriana, J., Permanasari, A., & Fitriani, A. (2016). Project Based Learning Integrated to STEM to Enhance Elementary School's Students Scientific Literacy. *Jurnal Pendidikan IPA Indonesia*, *5*(2), 261–267. https://doi.org/10.15294/jpii.v5i2.5493

Alameddine, N. (2021). Canadian Social Studies Supporting Muslim Students Through Culturally Relevant, Responsive, and Sustaining Pedagogies. *Canadian Social Studies*, *52*(2), 22-38. https://doi.org/10.29173/css20

Ali, A., Bektiarso, S., Walukow, A. F., & Narulita, E. (2025). Ethnoscience-Based Learning in Elementary Schools: A Systematic Literature Review. *TWIST*, *20*(1), 209-216. Retrieved from https://twistjournal.net/twist/article/view/617

Anggraini, A., Prassastie, F. E., Salani, H. T. N., Fahma, F. A., Rahman, À., & Dewi, A. F. (2025). Development of Ethnoscience Based Science Learning Module and Science Literacy for Junior High School Students. *Proceeding International Conference on Education*, 163–172. Retrieved from https://jurnalfaktarbiyah.iainkediri.ac.id/index.php/proceedings/article/view/6703

Ardianti, S. D., Wanabuliandari, S., & Tanghal, A. B. (2023). Implementation the Ethnoscience-Based Smart Module to Improve Students' Patriotism. *Jurnal Pendidikan IPA Indonesia*, *12*(2), 293–300. https://doi.org/10.15294/jpii.v12i2.43789

Ariani, T., & Hariyadi, B. (2024). Integration of Ethnoscience Approach in Physics Learning Based on Laboratory Practice: A Systematic Literature Review. *Jurnal Penelitian Pembelajaran Fisika*, *15*(3), 252–262. https://doi.org/10.26877/jp2f.v15i3.18765

Ariska, M., Akhsan, H., Murniati, M., Yusuf, M., & Sari, D. K. (2023). Pelatihan Pembuatan LKPD Berbasis Projek dengan Pendekatan Kearifan Lokal Topik Energi Terbarukan untuk Guru Fisika MGMP Kabupaten Ogan Ilir. *Jurnal Pendidikan dan Pengabdian Masyarakat*, *6*(4), 275–279. https://doi.org/10.29303/jppm.v6i4.5729

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

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. https://doi.org/10.33394/ijete.v1i2.11308

Braun, V., & Clarke, V. (2006). Using Thematic Analysis in Psychology. *Qualitative Research in Psychology*, *3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Burke, P., & Lehane, P. (2023). *Weaving the Literature on Integration, Pedagogy and Assessment: Insights for Curriculum and Classrooms REPORT 2 A Report Commissioned by the National Council for Curriculum and Assessment*. Retrieved from https://ncca.ie/media/6371/weaving-the-literature-on-integration-pedagogy-and-assessment.pdf

Dishon, G., & Gilead, T. (2020). Adaptability and Its Discontents: 21st- Century Skills and The Preparation for an Unpredictable Future. *British Journal of Educational Studies*. https://doi.org/10.1080/00071005.2020.1829545

Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W. M. (2021). How to Conduct a Bibliometric Analysis: An Overview and Guidelines. *Journal of Business Research*, *133*, 285–296. https://doi.org/10.1016/j.jbusres.2021.04.070

Eck, N. J. V., & Waltman, L. (2010). Software Survey: VOSviewer, a Computer Program for Bibliometric Mapping. *Scientometrics*, *84*(2), 523–538. https://doi.org/10.1007/s11192-009-0146-3

García-Peñalvo, F. J. (2021). Avoiding the Dark Side of Digital Transformation in Teaching. An Institutional Reference Framework for eLearning in Higher Education. *Sustainability (Switzerland)*, *13*(4), 1–17. https://doi.org/10.3390/su13042023

Gay, G. (2018). *Culturally Responsive Teaching: Theory, Research, and Practice*. Teachers College Press.

Halawa, S., Lin, T. C., & Hsu, Y. S. (2024). Exploring Instructional Design in K-12 STEM Education: A Systematic Literature Review. *International Journal of STEM Education*, *11*(1). https://doi.org/10.1186/s40594-024-00503-5

Herayanti, L., Fuaddunnazmi, F., & Sukroyanti, B. A. (2025). Development of Ethnoscience-Based Teaching Materials to Improve Students' Scientific Literacy. *Jurnal Kependidikan: Jurnal Hasil Penelitian dan Kajian Kepustakaan di Bidang Pendidikan, Pengajaran dan Pembelajaran*, *11*(1), 365. https://doi.org/10.33394/jk.v11i1.13429

Hramia, A. (2015). Applying the Framework for Culturally Responsive Teaching to Explore the Adaptations that Teach First Beginning Teachers Use to Meet the Needs of Their Pupils in School. *Cogent Education*, *2*(1). https://doi.org/10.1080/2331186X.2015.1108950

Huda, C. (2024). *Paradigma Pembelajaran IPA Berbasis Proyek Berdiferensiasi: Menyukseskan Kurikulum Merdeka Belajar Kampus Merdeka*. Retrieved from https://books.google.co.id/books/about/Paradigma_Pembelajaran_IPA_Berbasis_Proy.html?id=p8D5EAAAQBAJ&redir_esc=y

Jihannita, J., Fadly, W., Ekapti, R. F., Luthfiana, D., & Widowati, A. (2024). The Development of Science Module Integrated with Ethnoscience of Singo Barong Mask to Improve Scientific Literacy and Cultural Preservation Attitudes. *Journal of Innovation in Educational and Cultural Research*, *5*(2), 356–363. https://doi.org/10.46843/jiecr.v5i2.790

Juliantara, K. D., Astawa, I. W. P., & Ardana, I. M. (2024). STEM-Based Learning Module Oriented Towards Balinese Ethnomathematics to Enhance Students' Creative Mathematical Thinking Abilities. *Jurnal Pedagogi dan Pembelajaran*, *7*(2), 262–269. https://doi.org/10.23887/jp2.v7i2.83930

Maphumulo, T. B., & Biccard, P. (2024). Teachers Identified Challenges to Implement Differentiated Instruction in Mainstream Primary School Mathematics Classrooms. *Unnes Journal of Mathematics Education*, *13*, 55–65. https://doi.org/10.15294/ccwb1a43

Mariyono, D., & Akmal, N. A. H. (2024). Transformative Impact of AI on Multicultural Education: A Qualitative Thematic Analysis. *Edelweiss Applied Science and Technology*, *8*(5), 113–118. https://doi.org/10.55214/25768484.v8i5.1667

Marlina, L., Dariyani, N., Rolipa, R., Sriyanti, I., Sudirman, S., & Meilinda, M. (2024). Differentiated Learning in SMA Negeri 3 Banyuasin III. *AIP Conf. Proc.*, *3052*, 020006. https://doi.org/10.1063/5.0201822

Matiso, N. H. (2024). Optimising Culturally Responsive Pedagogies in Multicultural English Second Language Classrooms. *International Journal of Learning, Teaching and Educational Research*, *23*(11), 384–401. https://doi.org/10.26803/ijlter.23.11.20

Nurhasnah, nFn, Azhar, M., Yohandri, nFn, & Arsih, F. (2022). Ethno-STEM in Science Learning in Indonesia: A Systematic Literature Review. *Jurnal Kwangsan*, *10*(2), 147-163. https://doi.org/10.31800/jtp.kw.v10n2.p147--163

Nurkhasyanah, E., Khafid, M., & Nuswowati, M. (2025). Development of 3D Augmented Reality Assemblr Edu Media with A Project Based Learning Model Based on Local Wisdom of Cirebon Region to Improve Students' Science Literacy. *International Journal of Research and Review*, *12*(8), 396–412. https://doi.org/10.52403/ijrr.20250847

Ober, T. M., Lehman, B. A., Gooch, R., Oluwalana, O., Solyst, J., Phelps, G., & Hamilton, L. S. (2023). Culturally Responsive Personalized Learning: Recommendations for a Working Definition and Framework. *ETS Research Report Series*, *2023*(1), 1–14. https://doi.org/10.1002/ets2.12372

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., … Moher, D. (2021). The PRISMA 2020 Statement: An Updated Guideline for Reporting Systematic Reviews. *Journal of Clinical Epidemiology*, *134*, 178–189. https://doi.org/10.1016/j.jclinepi.2021.03.001

Pozas, M., Letzel, V., & Schneider, C. (2020). Teachers and Differentiated Instruction: Exploring Differentiation Practices to Address Student Diversity. *Journal of Research in Special Educational Needs*, *20*(3), 217–230. https://doi.org/10.1111/1471-3802.12481

Prabawati, M. A., Yamtinah, S., Bramastia, B., & Sidiq, A. S. (2023). Literature Review: Pembelajaran IPA Bermuatan Etno-STEAM sebagai Upaya Pemberdayaan Kemampuan Berpikir Kreatif Siswa Kurikulum Merdeka. *Prosiding SNPS (Seminar Nasional Pendidikan Sains)*. Retrieved from https://proceeding.uns.ac.id/snps/article/view/762

Qurniati, D., & Wahyudiati, D. (2023). Improving Students' STEM Skills Through the Development of an E-Learning Chemistry Book Integrated with Sasak Local Wisdom. *Jurnal Penelitian Pendidikan IPA*, *9*(12), 11181–11188. https://doi.org/10.29303/jppipa.v9i12.6278

Ridwan, R., Ramatni, A., Ikhlas, A., Gusnidar, G., Wahyuni, L., & Sawlani, D. K. (2024). Integrasi STEM dalam Kurikulum Mempersiapkan Generasi Masa Depan. *Edu Research*, *5*(4), 13-29. https://doi.org/10.47827/jer.v5i4.266

Rosadi, P., Lestari, Y. B., & Hadi, M. (2024). The Challenges in Implementing Differentiated Instruction in English Classes: A Case Study in an Eastern Indonesia Context. *Ethical Lingua: Journal of Language Teaching and Literature*, *11*(1). https://doi.org/10.30605/25409190.669

Sabir, A., Wang, Y., & Zou, G. (2024). Differentiation Strategies in a Multicultural Classroom: A Case Study in an Elementary School Article Info. *International Journal of Educatio Elementaria and*

Psychologia, *1*(6), 319–334. https://doi.org/10.70177/ijeep.v1i6.1462

Sani, R. A., Tanjung, Y. I., Sani, R. A., Nasution, B., Yohandri, Y., & Festiyed, F. (2024). Science Teachers' Understanding of Culturally Responsive Teaching on Independent Learning Curriculum. *Jurnal Penelitian Pendidikan IPA*, *10*(1), 156–164. https://doi.org/10.29303/jppipa.v10i1.4821

Sarwi, S., Marwoto, P., Susilaningsih, E., Lathif, Y. F., & Winarto, W. (2024). Science Learning STEM-R Approach: A Study of Students' Reflective and Critical Thinking. *Journal of Education and Learning*, *18*(2), 462–470. https://doi.org/10.11591/edulearn.v18i2.21080

Setiawan, I., & Sudarmin, P. (2023). Development of Project Based Ethno-STEM Online Learning Module to Increase Interpersonal Literacy and Learning Out-come. *Journal of Innovative Science Education*, *12*(2), 192–200. Retrieved from http://journal.unnes.ac.id/sju/index.php/jise

Suarta, I. M., Noortyani, R., Yarsama, K., & Adhiti, I. A. I. (2022). The Role of Teachers' Indigenous Knowledge and Cultural Competencies in Enhancing Students' Engagement and Learning Outcomes. *Journal of Ethnic and Cultural Studies*, *9*(1), 244–264. https://doi.org/10.29333/ejecs/1025

Sudirman, S., Sutikno, S., Indriyanti, D. R., Sumarni, W., & Rahayuningsi, M. (2025). Integration of Ethnoscience in Natural Science learning: Literacy Study. *Jurnal Penelitian Pendidikan IPA*, *11*(6), 68–77. https://doi.org/10.29303/jppipa.v11i6.9980

Suprapto, N., Prahani, B. K., & Cheng, T. H. (2021). Indonesian Curriculum Reform in Policy and Local Wisdom: Perspectives from Science Education. *Jurnal Pendidikan IPA Indonesia*, *10*(1), 69–80. https://doi.org/10.15294/jpii.v10i1.28438

Thomas, J., & Harden, A. (2008). Methods for the Thematic Synthesis of Qualitative Research in Systematic Reviews. *BMC Medical Research Methodology*, *8*. https://doi.org/10.1186/1471-2288-8-45

Tomlinson, C. A., & Imbeau, M. B. (2023). *Leading and Managing A Differentiated Classroom 2nd Edition Leading and Managing a Leading and Managing A Differentiated Classroom 2nd Edition*. Retrieved from www.ascd.org/deskcopy

Valiandes, S., & Neophytou, L. (2018). Teachers' Professional Development for Differentiated Instruction in Mixed-Ability Classrooms: Investigating the Impact of a Development Program on Teachers' Professional Learning and on Students' Achievement. *Teacher Development*, *22*(1), 123–138. https://doi.org/10.1080/13664530.2017.1338196

Wahyu, Y., Suastra, I. W., Sadia, I. W., & Suarni, N. K. (2020). The Effectiveness of Mobile Augmented Reality Assisted STEM-Based Learning on Scientific Literacy and Students' Achievement. *International Journal of Instruction*, *13*(3), 343–356. https://doi.org/10.29333/iji.2020.13324a

Wardani, D. S., Wulandari, M. A., Nurfurqon, F. F., & Kurniawati, D. (2021). STEM-Integrated Project-Based Learning (PjBL) Model and Lecture with Experiments Learning Model: What is The Scientific Literacy Skills of Elementary Teacher Education Students in These Learning Models? *Al-Bidayah: Jurnal Pendidikan Dasar Islam*, *13*(1), 55–72. https://doi.org/10.14421/al-bidayah.v13i1.634

Wardani, K. S. K., Astria, F. P., & Nurwahidah, N. (2023). Development of Ethnoscience-Based Science Education Module Using a Case Based Learning Model. *Jurnal Penelitian Pendidikan IPA*, *9*(SpecialIssue), 473–478. https://doi.org/10.29303/jppipa.v9ispecialissue.6123

Yulyanti, E., Maftukhin, A., & Akhdinirwanto, R. W. (2022). Development of Ethnoscience-Based Physics E-Module Using Kvisoft Flipbook Maker to Improve Students' Science Literacy Skills. *KONSTAN-Jurnal Fisika dan Pendidikan Fisika*, *7*(02), 134-143. https://doi.org/10.20414/konstan.v7i02.191

Zahro, F., Hariyono, E., & Setiawan, B. (2024). Inovasi Pembelajaran STEM Melalui Desain Prototipe Sistem Penyiraman Tanaman Otomatis Berbasis IoT untuk Siswa SMP. *Seminar Nasional Pendidikan Biologi IX*, *10*(1). Retrieved from https://research-report.umm.ac.id/index.php/snpb/article/view/255

Zidny, R., Sjöström, J., & Eilks, I. (2020). A Multi-Perspective Reflection on How Indigenous Knowledge and Related Ideas Can Improve Science Education for Sustainability. *Science and Education*, *29*(1), 145–185. https://doi.org/10.1007/s11191-019-00100-x