



Ethno-Techno-Science Pedagogy in Islamic Primary Schools: A Systematic Review of Indonesia's Merdeka Curriculum Implementation and Science Literacy Outcomes

Khalimatus Sa'diyah¹, Karno²

^a STAI Pati, Jalan Kampus Raya No. 5, Desa Dadirejo, Kecamatan Margorejo, Kabupaten Pati, Indonesia

^b STAI Pati, Jalan Kampus Raya No. 5, Desa Dadirejo, Kecamatan Margorejo, Kabupaten Pati, Indonesia

*[emailpenulis: abdhamidhalimah@gmail.com](mailto:abdhamidhalimah@gmail.com)

Diterima: Februari 2026

Disetujui: Maret 2026

Dipublikasikan: Maret 2026

ABSTRACT

This systematic review evaluates the implementation of the Merdeka Curriculum in Madrasah Ibtidaiyah (Islamic primary schools), focusing on the integration of ethno-techno-science approaches into science pedagogy. Following Cochrane methodology, six structured queries were run across Semantic Scholar, PubMed, OpenAlex, arXiv, and clinical trial databases. From 164 initial records, 23 studies met inclusion criteria after deduplication, screening, and full-text assessment. Risk of bias was assessed using adapted Cochrane tools, and GRADE was used to evaluate certainty of evidence. The findings show that implementation employs project-based learning and differentiated instruction, unifying natural and social sciences into the IPAS subject. Ethnoscience integration occurs through traditional biotechnology products, local agricultural practices, and cultural artifacts. Key barriers include insufficient teacher understanding (40% unprepared), limited infrastructure, and scarce training opportunities. One quasi-experimental study reported moderate improvement in science literacy (N-Gain = 0.46) after culture-based instruction. GRADE certainty ranged from very low to moderate across outcomes. The review concludes that while ethnoscience-integrated Merdeka Curriculum implementation is feasible and potentially beneficial for science literacy, evidence remains limited by qualitative designs and small sample sizes. Strengthening teacher capacity and infrastructure is critical for successful implementation.

Keywords: Merdeka Curriculum; Ethno-Techno-Science; Madrasah Ibtidaiyah; Science Pedagogy; Ethnoscience Integration; Systematic Review

ABSTRAK

Tinjauan sistematis ini mengevaluasi implementasi Kurikulum Merdeka di Madrasah Ibtidaiyah dengan fokus pada integrasi pendekatan etno-teknosains ke dalam pedagogi IPA. Mengikuti metodologi Cochrane, enam kueri terstruktur dijalankan pada basis data Semantic Scholar, PubMed, OpenAlex, arXiv, dan uji klinis. Dari 164 catatan awal, 23 studi memenuhi kriteria inklusi setelah penghapusan duplikat, penyaringan, dan penilaian teks lengkap. Risiko bias dinilai menggunakan alat Cochrane yang diadaptasi, dan GRADE digunakan untuk mengevaluasi kepastian bukti. Temuan menunjukkan bahwa implementasi Kurikulum Merdeka menggunakan pendekatan pembelajaran berbasis proyek dan pembelajaran berdiferensiasi, yang menyatukan ilmu pengetahuan alam dan sosial ke dalam mata pelajaran IPAS. Integrasi etnosains terjadi melalui produk bioteknologi tradisional, praktik pertanian lokal, dan artefak budaya. Hambatan utama meliputi pemahaman guru yang tidak memadai (40% guru belum siap), infrastruktur yang terbatas, serta minimnya pelatihan. Satu studi kuasi-eksperimen melaporkan peningkatan literasi sains dalam kategori sedang (N-Gain = 0,46) setelah pembelajaran berbasis budaya. Tingkat kepastian GRADE berkisar dari sangat rendah hingga sedang untuk berbagai luaran. Tinjauan ini menyimpulkan bahwa meskipun implementasi Kurikulum Merdeka dengan integrasi etnosains layak dilakukan dan berpotensi meningkatkan literasi sains siswa, bukti yang ada masih terbatas karena dominasi desain kualitatif dan ukuran sampel yang kecil. Penguatan kapasitas guru dan penyediaan infrastruktur yang memadai sangat kritis untuk keberhasilan implementasi.

Kata Kunci: Kurikulum Merdeka; Etno-Tekno-Sains; Madrasah Ibtidaiyah; Pedagogi IPA; Integrasi Etnosains; Tinjauan Sistematis.

INTRODUCTION

Indonesia's education system has undergone significant transformation with the introduction of Kurikulum Merdeka (Merdeka Curriculum), which represents a strategic response to learning loss resulting from the COVID-19 pandemic and broader educational reform goals (Himawan et al., 2025). This curriculum fundamentally restructures science education at the primary level through the integration of Ilmu Pengetahuan Alam (IPA/Natural Sciences) and Ilmu Pengetahuan Sosial (IPS/Social Sciences) into a unified subject called IPAS (Ilmu Pengetahuan Alam dan Sosial), designed to align with the holistic-concrete thinking characteristics of elementary students (Himawan et al., 2025).

Madrasah Ibtidaiyah, as Islamic primary educational institutions under the Ministry of Religious Affairs, face unique challenges in implementing this curriculum transformation. These institutions must harmonize policies from both the Ministry of Religious Affairs and the Ministry of Education, Culture, Research and Technology (Himawan et al., 2025). The complexity is further compounded by the need to integrate Islamic values while adapting to student-centered, project-based pedagogical approaches mandated by Kurikulum Merdeka.

The integration of ethnoscience, defined as indigenous knowledge encompassing language, customs, culture, morals, and traditional technologies containing scientific knowledge, has emerged as a promising approach to making science learning contextually relevant (Forniawan, 2023). This approach is particularly significant given the rapid globalization that has eroded Indonesian local cultural values (Puspasari et al., 2019). Learning that combines local cultural wisdom with natural science concepts enables students to understand scientific phenomena through familiar cultural experiences while preserving traditional knowledge (Forniawan, 2023).

Despite growing interest in culturally responsive science pedagogy, comprehensive synthesis of evidence regarding implementation patterns, integration mechanisms, and effectiveness outcomes at Madrasah Ibtidaiyah remains limited. The 2022 Programme for International Student Assessment (PISA) data shows Indonesian students ranked 64th out of 81 countries with a science literacy score of only 383 points,

far below the OECD average of 485 points (Sari et al., 2026). Furthermore, the 2023 Indonesian Madrasah Competency Assessment (AKMI) revealed that 61% of madrasah students remain in the sufficient category for science literacy (Sari et al., 2026).

This systematic review addresses three interconnected research questions: (1) What are the trends and patterns of Kurikulum Merdeka implementation in IPA/IPAS learning at Madrasah Ibtidaiyah? (2) How are ethnoscience and technoscience integrated into IPA pedagogy at Madrasah Ibtidaiyah? (3) What conceptual frameworks guide the transformation of IPA pedagogy at Madrasah Ibtidaiyah based on ethno-techno-science approaches?

Method

Eligibility Criteria

Studies were included if they addressed: (1) Madrasah Ibtidaiyah or Islamic primary schools as the educational setting; (2) primary school students (ages 6-12) as the target population; (3) Kurikulum Merdeka or independent curriculum implementation; (4) ethnoscience, technoscience, or culturally responsive science teaching approaches; (5) natural sciences (IPA) or IPAS curriculum domains; (6) implementation patterns, trends, barriers, or facilitators; (7) pedagogical transformation outcomes or integration mechanisms; and (8) Indonesian context or Indonesian-language sources. Studies were excluded if they addressed non-Indonesian contexts without direct relevance to Kurikulum Merdeka or Madrasah Ibtidaiyah implementation.

Information Sources and Search Strategy

Systematic searches were conducted across five databases: Semantic Scholar, PubMed, OpenAlex, arXiv, and clinical trial registries. Six structured queries were employed:

1. ("Madrasah Ibtidaiyah" OR "Islamic primary school*") AND ("Kurikulum Merdeka" OR "independent curriculum" OR "merdeka curriculum implementation")
2. ("Madrasah Ibtidaiyah" OR "Islamic elementary school") AND (ethnoscience OR "ethno-science" OR technoscience* OR "culturally responsive science")
3. "Kurikulum Merdeka" AND (IPA OR "science education" OR "natural sciences") AND (ethnoscience* OR technoscience* OR integration)

4. ("primary school* IPA" OR "elementary science curriculum" OR "Madrasah Ibtidaiyah science") AND ("pedagogical transformation" OR "curriculum integration" OR "conceptual framework")
5. "Kurikulum Merdeka" AND ("Madrasah Ibtidaiyah" OR "Islamic school*") AND (implementation OR adoption OR practice)
6. (ethnoscience* OR technoscience* OR "integrated science pedagog") AND (Madrasah OR "Islamic school" OR Indonesia) AND ("Kurikulum Merdeka" OR implementation)

Selection Process

The PRISMA flow documented 164 records identified through database searching. After removing 20 duplicates (by DOI), 144 unique records underwent screening. Three records were mechanically excluded due to missing abstracts. Title and abstract screening of 141 records resulted in exclusion of 107 records. Full-text assessment of 34 remaining articles led to exclusion of 11 articles, yielding 23 studies meeting inclusion criteria.

Data Extraction

Data were extracted using a standardized form capturing: implementation approach, cultural integration mechanism, curriculum framework, science subjects covered, grade levels targeted, integration elements, learning resource types, research design, sample size, participant characteristics, madrasah location, implementation phase, effectiveness measures, identified challenges, supporting factors, teacher readiness aspects, and policy references.

Risk of Bias Assessment

Risk of bias was assessed using adapted Cochrane Risk of Bias tools appropriate for each study design. Domains assessed included: randomization process, deviations from intended interventions, missing outcome data, measurement of outcome, and selection of reported results. Ratings were assigned as Low (L), Some Concerns (SC), High (H), Serious (S), Critical (CR), or Not Applicable (not _).

Certainty of Evidence Assessment (GRADE)

The certainty of evidence for each outcome was assessed using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach,

considering risk of bias, inconsistency, indirectness, imprecision, and publication bias. Certainty ratings ranged from very low to high.

RESULTS AND DISCUSSION

Results

1. Included Study Characteristics

This systematic review included 23 studies examining Kurikulum Merdeka implementation and ethnoscience integration in science education at Madrasah Ibtidaiyah or equivalent primary settings in Indonesia. The included studies comprised: Silka Yumna et al. (2025), Very Himawan et al. (2025), Lia Wanti et al. (2023), Ary Forniawan (2023), Leli Lestari et al. (2025), Rita Sari et al. (2026), N. Aisyah et al. (2023), Mardhiyati Ningrum et al. (2023), Siti Aisyah et al. (2023), Anas Anas et al. (2023), Nasarudin Nasarudin et al. (2023), Eko Bayu Gumilar (2023), Kasmah Kasmah et al. (2023), M. Sumarni et al. (2026), Surya Haryandi et al. (2023), Anggitiyas Sekarinasih et al. (2025), Salmilah Salmilah et al. (2024), Jurnal Pendidikan Pascasarjana et al. (2025), Ali Imron (2023), Irsan Hadi et al. (2025), Aulia Dwi Putri Sofian et al. (2025), Afrin Puspasari et al. (2019), and Heni Yunilda Hasibuan et al. (2023).

Research designs were predominantly qualitative descriptive (n=15), with literature reviews (n=5), one quasi-experimental study, and two mixed-methods studies. Geographic coverage included Central Java (Semarang City), East Java (Probolinggo, Surakarta), South Sulawesi (Watampone), Aceh Province (Langsa), South Sumatra (Palembang), West Kalimantan (Bengkayang), and Lampung Province. Sample sizes ranged from 10 to 80 students, with teacher participants ranging from 1 to 55 across studies.

2. Implementation Success of Kurikulum Merdeka in IPA/IPAS Learning

Five studies provided evidence regarding implementation success patterns at Madrasah Ibtidaiyah. The implementation approach consistently emphasized project-based learning (PjBL) and inquiry methods (Himawan et al., 2025). At MI Miftahul Huda Banyuanyar Probolinggo, the Kurikulum Merdeka brought significant changes in teaching methods and learning material design, with the integration of IPA and IPS encouraging students to understand the relationship

between natural and social phenomena in an integrated manner (Himawan et al., 2025).

The curriculum framework adopted the integration of IPA and IPS into unified IPAS subjects starting from Grade III, with learning beginning in the 2022-2023 academic year and expanding to all grades (1-6) by 2024-2025 (Himawan et al., 2025). Teachers implemented active learning methods including group discussions, video-based instruction, and project-based learning (P5RA) to enhance student participation (Himawan et al., 2025).

At MIN of Semarang City, implementation has been effective despite facing obstacles, with differentiated learning approaches combined with learning style-based strategies (visual, auditory, kinesthetic) (Imron, 2023). Teachers utilize the Merdeka Belajar platform to develop their knowledge and skills in planning and executing courses adhering to Merdeka Curriculum principles (Imron, 2023). The implementation structure includes intra-curricular learning and learning through projects for strengthening the achievement of the Pancasila student profile (Imron, 2023).

GRADE Certainty: Low. The evidence is downgraded due to risk of bias (predominantly qualitative designs without control groups) and indirectness (variable implementation contexts and outcome measures).

3. Integration of Ethnoscience/Local Wisdom into IPA/IPAS Pedagogy

Four studies provided detailed evidence on ethnoscience integration mechanisms. At Madrasah Ibtidaiyah Al-Munawaroh, ethnoscience-based biotechnology learning resources were implemented focusing on traditional fermented food products including tempe, peuyeum, and bread (Forniawan, 2023). All 49 students (100%) recognized these products as consumed daily with preparation methods inherited through generations (Forniawan, 2023). However, only 35% of students understood the microorganisms involved in fermentation, and 32% comprehended fermentation mechanisms (Forniawan, 2023).

The Seuramoe Sientia model developed for MIN 2 Langsa, Aceh, represents a comprehensive culture-based science learning framework integrating the traditional seuneubok (land management) system through five instructional phases: Cultural Orientation, Context Exploration, Knowledge Construction, Artefact Creation, and

Global Reflection and Expansion (Sari et al., 2026). Students engaged with traditional tools (cangkoi, lhamm, langai) as cognitive bridges between cultural heritage and scientific concepts (Sari et al., 2026).

At SD Muhammadiyah Alam Surya Mentari Surakarta, ethnosience implementation occurred unconsciously, integrating material with environment, culture, and social context (Puspasari et al., 2019). The Kurikulum Merdeka policy has been implemented extensively since 2022 with one focus being cultural integration in teaching and learning (Hasibuan et al., 2023).

The literature review by M. Sumarni et al. (2026) identified integration of Dayak tribe local wisdom in Bengkayang Regency, including ethnobotanical practices of medicinal plants and traditional agricultural rituals, demonstrating high effectiveness with success rates up to 97.41% in increasing learning interest and critical thinking skills (Sumarni et al., 2026).

GRADE Certainty: Very Low. Evidence is downgraded due to serious risk of bias, inconsistency in outcome measures, and imprecision from small sample sizes and predominantly qualitative designs.

4. Teacher Readiness and Pedagogical Capacity

Three studies evaluated teacher readiness for implementing culturally-integrated Kurikulum Merdeka. At Madrasah Ibtidaiyah in Watampone City, only 27% of teachers were ready regarding understanding of Kurikulum Merdeka policies, with 40% in the unprepared category (Kasmah et al., 2023). However, 60% of teachers were very prepared in formulating learning objectives for Pancasila student profiles, and 55% were very ready to implement 21st-century learning (Kasmah et al., 2023).

Inhibiting factors identified include: (a) lack of experience in applying the Merdeka Belajar approach due to previous centralized syllabi limiting instructors' ability to innovate (Imron, 2023); (b) limited references and access to learning resources with constraints of internet, digital gadgets, and their utilization impeding educational transformation (Imron, 2023); and (c) limited facilities and amenities (Hadi et al., 2025).

At MI Miftahul Huda Banyuwangi, the main challenges include teachers' initial lack of understanding of the IPAS concept and limited supporting resources

(Himawan et al., 2025). Teachers required adaptation in designing effective teaching strategies, particularly regarding the integration of IPA and IPS materials (Himawan et al., 2025). Insufficient training participation resulted in inadequate integration of IPAS in every learning process (Himawan et al., 2025).

Supporting factors include active participation of teachers and schools, utilization of the Merdeka Belajar platform (Imron, 2023), continuous evaluation and improvement cycles, and supervisor accompaniment (Imron, 2023).

GRADE Certainty: Low. Evidence downgraded for risk of bias and indirectness across heterogeneous educational contexts.

5. Student Learning Outcomes and Science Literacy

Two studies provided quantitative evidence on learning outcomes. The Seuramoe Saientia model implementation demonstrated significant improvement in students' science literacy with mean pre-test score of 61.8 increasing to 79.4 in post-test, yielding an N-Gain of 0.46 (moderate category) (Sari et al., 2026). Statistical analysis indicated significant difference between pre- and post-test scores ($t = 5.37$; $p < 0.05$) (Sari et al., 2026). Observational findings revealed enhanced ecological awareness, collaborative skills, and ability to connect scientific concepts with local cultural values (Sari et al., 2026).

Development of ethnoscience-based e-modules on Arabica Java Ijen-Raung coffee plant achieved 93% validity score, 79.28 effectiveness score (N-Gain, effective category), and 94% practicality score (Sofian et al., 2025).

Positive impacts reported include changes in learning methods and innovations, development of independence, creativity, and student initiative, as well as increased student collaboration (Imron, 2023). Students gained opportunities to search for learning materials independently through the internet, developing independence in finding relevant and quality learning resources (Imron, 2023).

GRADE Certainty: Very Low. Single quasi-experimental study with small sample ($N=25$), lack of control group, and potential selection bias severely limit confidence in effect estimates.

6. Structural Feasibility and Implementation Barriers

Six studies provided convergent evidence on implementation barriers with moderate certainty. The research at MI Al-Ishlah Palembang confirmed that limited

classroom space, inadequate sanitation facilities, and insufficient information technology devices have direct impact on implementation of differentiated learning, P5RA projects, and technology-based instruction (Hadi et al., 2025).

Consistent barriers identified across studies include: (1) teachers' lack of initial understanding of IPAS concept and limited supporting resources (Himawan et al., 2025); (2) reduced IPS content within IPAS with materials only appearing at semester end (Himawan et al., 2025); (3) difficulty identifying and developing IPS competencies specifically within IPAS structure (Himawan et al., 2025); (4) limited availability of IPAS textbooks in Madrasah environment (Himawan et al., 2025); and (5) assessment practices still focusing on factual knowledge rather than critical thinking and problem-solving competencies (Himawan et al., 2025).

The integration of IPA and IPS presents complex challenges in curriculum design, requiring teachers to understand concepts from two disciplines and design collaborative project-based learning (Himawan et al., 2025). At class level, students in Grade IV frequently experienced difficulty connecting IPS and IPA concepts, while Grade V students demonstrated greater capability in identifying relationships between social and natural phenomena (Himawan et al., 2025).

Infrastructure challenges particularly affect madrasah in rural areas, where facilities and amenities required for Merdeka Curriculum implementation remain limited (Imron, 2023). The implementation of two-session learning due to space constraints impacts effectiveness of study time (Hadi et al., 2025).

GRADE Certainty: Moderate. Strong qualitative consensus across six studies identifies consistent implementation barriers with coherent thematic patterns, though limited by absence of quantitative measurement.

Discussion

1. Summary of Findings

This systematic review synthesizes evidence from 23 studies examining Kurikulum Merdeka implementation and ethnoscience integration in IPA/IPAS learning at Madrasah Ibtidaiyah. The evidence reveals several key findings regarding implementation patterns, integration mechanisms, and pedagogical transformation.

The implementation of Kurikulum Merdeka at Madrasah Ibtidaiyah demonstrates a consistent pattern of project-based learning adoption with

differentiated instruction approaches (Himawan et al., 2025). The curriculum's integration of IPA and IPS into unified IPAS subjects represents a paradigm shift from separate disciplinary instruction to holistic learning aligned with elementary students' concrete-holistic thinking characteristics (Himawan et al., 2025). Schools have adopted the Merdeka Belajar platform and supervisor accompaniment as key supporting mechanisms (Imron, 2023).

Ethnoscience integration occurs through multiple mechanisms including traditional biotechnology products (tempe, peuyeum, bread) (Forniawan, 2023), regional land management practices (seuneubok system) (Sari et al., 2026), and local agricultural traditions (Sumarni et al., 2026). These approaches demonstrate feasibility in connecting scientific concepts with students' cultural experiences, though comprehensive understanding of underlying scientific mechanisms remains limited among students.

Teacher readiness emerges as a critical implementation factor, with evidence indicating significant gaps, 40% of teachers demonstrating inadequate understanding of curriculum policies (Kasmah et al., 2023). This finding aligns with reported challenges including limited training opportunities, insufficient IPAS concept understanding, and inadequate supporting resources (Himawan et al., 2025).

2. Conceptual Framework for Ethno-Techno-Science Pedagogy

Based on the synthesized evidence, a conceptual framework for transforming IPA pedagogy at Madrasah Ibtidaiyah emerges with three interconnected dimensions:

- a. **Dimension 1:** Cultural Orientation and Context Exploration. This dimension involves introducing local cultural practices with scientific relevance as learning entry points (Sari et al., 2026). The Seuramoe Sientia model exemplifies this through cultural orientation phases that build cognitive bridges between traditional knowledge and scientific concepts (Sari et al., 2026).
- b. **Dimension 2:** Knowledge Construction through Authentic Practice. Students engage in hands-on activities connecting cultural practices with scientific inquiry, such as food chain structuring using local ecological examples (Sari et al., 2026) or fermentation experiments with traditional foods (Forniawan, 2023).

This dimension addresses the need for contextual learning that makes abstract scientific concepts tangible.

- c. **Dimension 3:** Reflection and Global Expansion. Students connect local knowledge with broader scientific principles and sustainable development goals (Sari et al., 2026). This phase enables critical reflection on how traditional ecological knowledge contributes to environmental conservation (Sari et al., 2026).

3. Strengths and Limitations of the Evidence

The evidence base demonstrates several strengths. The geographic diversity of included studies—spanning Central Java, East Java, Aceh, South Sulawesi, South Sumatra, West Kalimantan, and Lampung—provides insight into implementation variation across Indonesia's diverse educational contexts. The consistent identification of implementation barriers across multiple studies (moderate GRADE certainty) strengthens confidence in these findings.

However, significant limitations constrain interpretation. The predominance of qualitative descriptive designs (15 of 23 studies) limits causal inference regarding effectiveness outcomes. The single quasi-experimental study (N=25) demonstrating science literacy improvement (Sari et al., 2026) lacks a control group, introducing potential selection and confounding bias. Sample sizes are generally small, and risk of bias ratings indicate "some concerns" across most domains for quantitative outcomes.

The very low certainty evidence for ethnoscience integration effectiveness and student learning outcomes means that while the approaches appear promising, definitive conclusions about their impact cannot be drawn from current evidence. The low certainty evidence for implementation success and teacher readiness suggests these patterns are likely but remain subject to revision with higher-quality evidence.

4. Comparison with Prior Reviews

This review extends previous systematic analyses by Hasibuan et al. (2023), which examined ethnoscience integration in science education broadly (Hasibuan et al., 2023). While that review identified only six suitable articles published between 2022-2023 across various educational levels, the present review specifically focuses

on Madrasah Ibtidaiyah context with 23 included studies, providing more comprehensive coverage of this institutional setting.

The findings align with broader literature documenting challenges in curriculum reform implementation in Indonesian schools. The teacher readiness gaps identified (40% unprepared for curriculum policies) (Kasmah et al., 2023) mirror challenges reported in general primary school settings, suggesting these barriers are not unique to Madrasah Ibtidaiyah but reflect systemic implementation challenges.

5. Implications for Practice

Given moderate certainty evidence regarding implementation barriers, educational policymakers and school administrators should prioritize: (1) intensive teacher training on IPAS concept integration and Kurikulum Merdeka principles; (2) development and distribution of standardized IPAS teaching materials incorporating local cultural content; and (3) infrastructure investment to support project-based and technology-enhanced learning.

Given low certainty evidence for teacher readiness outcomes, Madrasah Ibtidaiyah should implement graduated implementation approaches with ongoing supervisor support (Imron, 2023) and utilize the Merdeka Belajar platform for professional development (Imron, 2023).

Given very low certainty evidence for student learning outcomes, practitioners should implement ethnoscience-based approaches with systematic monitoring and evaluation rather than assuming effectiveness. The Seuramoe Sientia model's five-phase structure (Sari et al., 2026) offers a validated framework for culture-based instruction, though replication studies are needed.

6. Implications for Research

Future research should prioritize: (1) quasi-experimental or randomized controlled trials with adequate sample sizes to establish causal effects of ethnoscience integration on science literacy; (2) development and validation of standardized instruments for measuring ethno-techno-science integration quality; (3) longitudinal studies tracking student outcomes across implementation phases; and (4) comparative studies across different regional cultural contexts to identify transferable versus context-specific implementation strategies.

Studies should explicitly report implementation fidelity measures and utilize appropriate control conditions to enable stronger causal inference. Multi-site studies with larger samples would address current imprecision limitations.

CONCLUSION

This systematic review synthesizes evidence from 23 studies examining Kurikulum Merdeka implementation and ethnoscience integration in IPA/IPAS learning at Madrasah Ibtidaiyah in Indonesia. Moderate certainty evidence identifies consistent implementation barriers including limited teacher understanding, insufficient infrastructure, and inadequate training opportunities. Low certainty evidence suggests that implementation can be successful with appropriate support structures, while very low certainty evidence indicates that ethnoscience integration may improve science literacy outcomes, though definitive conclusions await higher-quality studies. The conceptual framework emerging from this synthesis, encompassing cultural orientation, authentic knowledge construction, and global reflection dimensions, provides guidance for practitioners, but implementation should be accompanied by systematic evaluation. Strengthening teacher capacity through intensive training and ensuring adequate infrastructure represent priority interventions for successful Kurikulum Merdeka implementation at Madrasah Ibtidaiyah.

REFERENCES

- Forniawan, A. (2023). Implementasi sumber belajar bioteknologi berbasis etnosains di madrasah ibtidaiyah al-munawaroh. *Al Jahiz: Journal of Biology Education Research*, 3(2), 133-144. <https://doi.org/10.32332/al-jahiz.v3i2.5884>
- Falah, A. (2025). Penerapan Penggunaan Media Digital Dalam Menumbuhkan Kesadaran Budaya Baca Siswa. <https://Journal.Metanusantara.Com/Pedagogia/Index.Php/Jkp>, 2(01), 28–34.
- Faricha, F., & Sariman, S. (2024). Peran Lembaga Pendidikan Islam Pada Dalam Membentuk Generasi Muslim Yang Kompetitif. *Al Fattah Ejournal Sma Al Muhammad Cepu*, 5(02), 36–57.
- Fatoni, I. (2024). Transformasi Pendidikan Melalui Kurikulum Merdeka Belajar: Studi Tren Model Pembelajaran Di Sekolah Dan Madrasah. <https://Journal.Metanusantara.Com/Pedagogia/Index.Php/Jkp>, 1(01), 27–36.
- Hadi, I., Sriwidjaya, A. L. P., & Jirniati. (2025). Challenges for implementing the independent curriculum (kurikulum merdeka): An analysis of facilities and infrastructure inequality at madrasah ibtidaiyah al-ishlah palembang. *AR-RIAYAH: Jurnal Pendidikan Dasar*, 9(2), 245–254. <https://doi.org/10.29240/jpd.v9i2.14976>
- Hasibuan, H. Y., Syarifudin, E., Suherman, S., & Santosa, C. A. H. F. (2023). Ethnoscience as the policy implementation of kurikulum merdeka in science learning: A systematic literature review. *Jurnal Penelitian Pendidikan IPA*, 9(8), 366–372. <https://doi.org/10.29303/jppipa.v9i8.4500>
- Himawan, V., Sahertian, P., & Kusufa, R. A. B. (2025). Implementasi Kurikulum Merdeka terhadap Pembelajaran IPS di Madrasah Ibtidaiyah Miftahul Huda Banyuwangi Probolinggo. *Dinamika Sosial: Jurnal Pendidikan Ilmu Pengetahuan Sosial*, 4(2), 128-134. <https://doi.org/10.18860/dsjpips.v4i2.16228>
- Habibah, N. (2025). Implementasi Pola Asuh Positif dan Implikasinya terhadap Perkembangan Sosial Emosional Anak Usia Dini di Lembaga PAUD. *Pedagogia: Jurnal Pendidikan Dan Keguruan*, 1(1), 610250.
- Hana, Y. (2025). Analisis Keterampilan Berpikir Kritis Siswa Melalui Pendekatan Pembelajaran Berbasis Masalah. <https://Journal.Metanusantara.Com/Pedagogia/Index.Php/Jkp>, 2(01), 35–43.
- Haryono, E., Rangkuti, Rizki Kurniawan, Sariman, S., & Suprihatiningsih, S. (2024). Metodologi Penelitian Kualitatif dan Kuantitatif . <https://Www.Rcipress.Rcipublisher.Org/Index.Php/Rcipress/Catalog/Book/949>. Perkumpulan Rumah Cemerlang Indonesia.
- Imron, A. (2023). The implementation of merdeka curriculum in piloting madrasa; a case study at state madrasah ibtidaiyah of semarang city. *Al Ibtida Jurnal Pendidikan Guru MI*, 10(2), 326-336. <https://doi.org/10.24235/al.ibtida.snj.v10i2.14749>
- Kasmah, K., Syarmadana, S., & Harmida, H. (2023). Evaluation of the readiness of madrasah ibtidaiyah teachers in the implementation of the kurikulum merdeka.

- Vol. 1 (2023): Proceedings The 1st Syekhnurjati International Conferences on Elementary Education*, 124-133. <https://doi.org/10.24235/sicee.v1i0.14651>
- Manasik Jauharul, S.-S. (2025). Determinansi Kinerja Guru: Sintesis Literatur Terhadap Variabel Kompensasi, Loyalitas, dan Faktor Psikologis Kerja. *Genius: Jurnal Ekonomi Dan Manajemen*, 2(02), 12–25.
- Puspasari, A., Susilowati, I., Kurniawati, L., Utami, R. R., Gunawan, I., & Sayekti, I. C. (2019). Implementasi etnosains dalam pembelajaran IPA di SD muhammadiyah alam surya mentari surakarta. *SEJ (Science Education Journal)*, 3(1), 25-31. <https://doi.org/10.21070/SEJ.V3I1.2426>
- Sari, R., Maksudin, M., Ibrahim, I., Mardianto, M., & Sapri, S. (2026). Development of the seuramoe saientia model based on acehnese culture for science literacy of madrasah ibtidaiyah students. *Scaffolding: Jurnal Pendidikan Islam Dan Multikulturalisme*, 8(1), 977-997. <https://doi.org/10.37680/scaffolding.v8i1.9024>
- Sofian, A. D. P., Nuriman, N., Wardani, R., & Ramasamy, S. (2025). Development of ethnoscience-based e-modules on arabica java ijen-raung coffee plant to improve learning outcomes of grade IV elementary students. *Jurnal Pendidikan Sains Indonesia*, 13(1), 112-126. <https://doi.org/10.24815/jpsi.v13i1.41524>
- Sumarni, M., Jewarut, S., Melati, F. V., Vuspitasari, B. K., Atlantika, Y. N., & Siokalang, M. A. (2026). Potensi Pembelajaran IPAS dalam Memperkenalkan Kearifan Lokal di Sekolah Dasar. *SOCIAL: Jurnal Inovasi Pendidikan IPS*, 6(1), 292–302. <https://doi.org/10.51878/social.v6i1.9386>
- Sari, K. P. (2025). Konsep deep learning sebagai pilar dalam strategi pendidikan berkualitas. *Pedagogia: Jurnal Keguruan Dan Pendidikan*, 1(02), 11–19.
- Sariman, S., Huda, C., & Afif, M. N. (2021). Pengembangan Mutu Peserta Didik dalam Pembelajaran: Implementasi Profesionalisme Guru Madrasah. *Jurnal Pendidikan Agama Islam Al-Thariqah*, 6(2), 317–341.
- Sariman, S., & Mutaqien, F. Z. (2025). Intervensi Psikologi Pendidikan untuk Mengurangi Kecemasan Asesmen di Kalangan Santri Pesantren. *Al Fattah Ejournal Sma Al Muhammad Cepu*, 6(01), 21–30.