Islamic Journal of Integrated Science Education (IJISE), Vol. 5 No. 2, July 2026, pp. 219-242
DOI: https://doi.org/10.30762/ijise.v5i2.8759

Islamic Journal of Integrated Science Education (IJISE)

Program Studi Tadris IPA
Universitas Islam Negeri (UIN) Syekh Wasil Kediri
e-ISSN : 2986-0865
https://jurnalfaktarbiyah.iainkediri.ac.id/index.php/ijise

RECONSTRUCTING TECHNOLOGY-BASED SCIENCE EDUCATION IN INDONESIA: A GLOCAL FRAMEWORK INTEGRATING ISLAMIC VALUES, LOCAL ETHNOSCIENCE, AND EPISTEMIC JUSTICE WITHIN THE UNESCO–SDGS AGENDA

Eka Imbia Agus Diartika[1,2], Siti Maryam[1]*, Zahid Zufar At Thaariq[3]

[1]Biology Education, Universitas Negeri Malang, Indonesia
[2]Bioentrepreneurship, Institut Teknologi Bisnis dan Kesehatan Ahmad Dahlan Jawa Timur
[3]Cukurova University, Turkey

***Correspondence E-mail:** siti.maryam.2503419@students.um.ac.id

Abstract: Science education in Indonesia faces challenges in integrating global sustainability agendas with local knowledge, Islamic values, and educational technology. This conceptual paper critically reviews and synthesizes 20 core sources (10 global policy/SDG frameworks and 10 local context/ethnoscience/Islamic science studies) through thematic interpretation and comparative conceptual analysis. The findings reveal tensions between standardized science education and locally grounded knowledge systems, alongside unequal technological access. In response, the proposed Glocal Science Education framework positions UNESCO–SDGs as a global normative orientation, Islamic values as an ethical foundation, local ethnoscience as a contextual epistemological resource, and educational technology as a mediator connecting diverse knowledge systems. The framework promotes epistemic justice through epistemic pluralism, contextual relevance, ethical integration, and equitable global–local knowledge engagement. It provides a conceptual foundation for future empirical research and curriculum development in Indonesia.

Keywords: Glocal Science Education; Educational Technology; Islamic Values; Local Ethnoscience; Epistemic Justice

Article History:
Received: 01 May 2026; Revised: 07 July 2026; Accepted: 30 July 2026; Published: 31 July 2026

Citation (APA Style):
Diartika, E. I. A., Maryam, S., & At Thaariq, Z. Z. (2026). Reconstructing Technology-Based Science Education In Indonesia: A Glocal Framework Integrating Islamic Values, Local Ethnoscience, and Epistemic Justice Within The UNESCO–SDGs Agenda. *Islamic Journal of Integrated Science Education (IJISE), 5*(2), 219–242. https://doi.org/10.30762/ijise.v5i2.8759

INTRODUCTION

Science education in Indonesia is increasingly shaped by global education agendas, particularly UNESCO Education 2030 and the Sustainable Development Goals (SDGs), with SDG 4 emphasising inclusive, equitable, and quality education (United Nations, 2015; UNESCO, 2017). Within this framework, science education is positioned as a strategic vehicle for fostering scientific literacy, 21st-century competencies, environmental sustainability, and technological readiness. Indonesia's response to these global commitments is reflected in national policies such as the Merdeka Curriculum, which promotes student-centered learning, STEM–STEAM integration, digital literacy, project-based learning, and authentic assessment (Kemendikbudristek, 2022).

Despite this normative alignment, a substantial gap persists between the theoretical construction of global policy frameworks and the realities of science education practice in Indonesia. While the Merdeka Curriculum conceptually embodies UNESCO's vision of transformative and technology-enhanced learning, its implementation is constrained by structural, pedagogical, and contextual limitations. Many schools are expected to conduct technology-based science projects despite limited laboratory facilities, uneven internet access, and insufficient digital infrastructure. At the same time, teachers are encouraged to adopt higher-order thinking skills (HOTS) and STEAM-oriented pedagogies, even though professional development opportunities and pedagogical support remain unevenly distributed across regions (OECD, 2020; Kemendikbudristek, 2022). These conditions highlight a persistent policy–practice gap, suggesting that the core challenge lies not only in curriculum design, but also in the misalignment between universal global standards and the heterogeneous readiness of Indonesia's educational ecosystem.

Beyond implementation issues, this gap intersects with a deeper epistemological problem: epistemic injustice in science education. The dominant adoption of UNESCO–SDGs policies tend to privilege global, universalised forms of scientific knowledge while providing limited space for local Indonesian epistemologies, including indigenous ecological knowledge, community-based scientific practices, and culturally embedded ways of knowing. This condition produces an epistemic representational gap, in which global scientific narratives dominate curriculum and pedagogy at the expense of locally meaningful knowledge, thereby reducing the contextual relevance of science learning (Aikenhead, 2006; Fricker, 2007).

In the Indonesian context, this epistemological issue is also relevant to the relationship between science and Islamic knowledge traditions. As a predominantly Muslim country with diverse Islamic educational institutions, Indonesia has developed various approaches to integrating Islamic values and scientific knowledge in education. Research on Indonesian Islamic schools indicates that science–religion integration can be developed through an Islamic worldview that enables students to relate scientific understanding to broader religious and ethical considerations (Sahil et al., 2024). Similarly, the mapping of scientific and religious competencies has been proposed as a foundation for developing integrated science learning that connects scientific knowledge with Islamic values (Purwati et al., 2023). From a broader curricular perspective, Islamic science education in Indonesia has also been conceptualised as an integrative effort involving natural sciences, social sciences, humanities, and Indonesian contexts rather than treating Islam and science as isolated domains (Muttaqin, 2018). Thus, the incorporation of Islamic values into science education should not be reduced to the addition of religious references to scientific content; rather, it can provide an ethical and worldview-oriented dimension through which scientific knowledge, human responsibility, and the natural world are understood in an integrated manner (Al-Hidabi & Aljaji, 2020).

This perspective provides an important extension to the epistemic justice debate in science education. Epistemic justice does not necessarily require replacing established scientific knowledge with local or religious knowledge. Instead, it calls for more equitable recognition of diverse ways of knowing and greater attention to whose knowledge is represented, whose perspectives are legitimised, and how knowledge systems can meaningfully interact (Fricker, 2007). In this regard, Islamic values and local ethnoscience can function as complementary epistemological and ethical resources within science education. Local ethnoscience provides contextually grounded knowledge derived from communities and their interactions with local environments, while Islamic values can contribute ethical orientations concerning knowledge, human responsibility, stewardship of nature, and the pursuit and use of scientific knowledge. Such integration is consistent with efforts to reconstruct science education in Indonesia through an approach that connects Islam, science, and Indonesian socio-cultural contexts (Muttaqin, 2018).

Simultaneously, an epistemic access gap emerges through unequal access to technology-mediated knowledge. The digital transformation of education, normatively framed as an instrument of equity, often benefits well-resourced schools while marginalising those in underdeveloped and remote areas. Disparities in digital infrastructure, teacher competence, and institutional capacity risk reproducing epistemic injustice by determining who can access, produce, and legitimate scientific knowledge (Selwyn, 2016; OECD, 2020). In this context, educational technology has not fully functioned as an emancipatory tool for empowering local knowledge systems. Therefore, technology-based science education requires a broader conception of access that extends beyond physical connectivity and digital skills to include equitable access to diverse knowledge systems, culturally meaningful learning resources, and opportunities for learners to participate in knowledge production.

These epistemic challenges underscore the need to move beyond technocratic solutions focused solely on infrastructure and skills development. Instead, a critical epistemological reconstruction of science education is required, one that interrogates the assumptions underlying global policy adoption and seeks a more equitable integration of international, local, and Islamic epistemological and ethical perspectives. Such reconstruction requires positioning global agendas, local knowledge, Islamic values, and educational technology in complementary rather than hierarchical relationships. UNESCO–SDGs can provide a global normative orientation for inclusive and sustainable education; local ethnoscience can provide contextual and place-based epistemological resources; Islamic values can provide ethical and worldview-oriented foundations; and technology can mediate interaction among these knowledge resources while expanding opportunities for participation and knowledge exchange.

Accordingly, this study addresses the gap by proposing a conceptual framework for reconstructing technology-based science education in Indonesia that aligns with UNESCO–SDGs as a normative-ethical reference, Islamic values as an ethical and worldview-oriented foundation, local Indonesian ethnoscience as an epistemological and pedagogical resource, and educational technology as a mediating mechanism for advancing epistemic justice. Rather than positioning global science, Islamic knowledge, local ethnoscience, and technology as competing domains, the proposed framework conceptualises their interaction within a glocal orientation in which global educational aspirations are critically reinterpreted through Indonesian cultural, epistemological, and ethical contexts.

The objectives of this conceptual study are to: (1) critically analyse the epistemological foundations of UNESCO–SDGs policies and their implications for technology-based science education in Indonesia; (2) examine local Indonesian ethnoscience and Islamic values and their relevance to science curriculum and pedagogy; (3) conceptualise the hybridisation of global, local, and Islamic epistemological and ethical perspectives as a basis for epistemically just science education; and (4) propose a Glocal Science Education framework for reconstructing technology-based science education that integrates UNESCO–SDGs, Islamic values, local ethnoscience, educational technology, and epistemic justice.

While existing paradigms—such as place-based education, culturally responsive science, ethnoscience, and decolonial pedagogy—offer valuable frameworks for localizing learning, they often treat local knowledge, global standards, religious ethics, and digital technology in isolation. To bridge this gap, this study proposes the Glocal Science Education Framework. The explicit novelty of this model lies in its multi-layered synthesis, integrating four interconnected pillars into a unified operational workflow: (1) UNESCO–SDGs global policy alignment, (2) local ethnoscience epistemologies, (3) Islamic integrated science values (*Tawhid*, *Khalifah*, *Maslahah*), and (4) educational technology as an emancipatory epistemic mediator.

METHOD

This study is a conceptual paper that develops a critical framework for reconstructing technology-based science education in Indonesia from a UNESCO–SDGs perspective. Rather than generating empirical findings, the study aims to construct a theoretically grounded framework through critical examination of relevant literature and epistemological reasoning. A critical literature review was employed to examine key concepts, theoretical perspectives, and emerging discourses relevant to UNESCO–SDGs, Education for Sustainable Development (ESD), science education, educational technology, local ethnoscience, Islamic integrated science, and epistemic justice.

Relevant literature was identified from peer-reviewed international and Indonesian journals (including SINTA-indexed journals in integrated science education), complemented by key policy and conceptual documents from UNESCO, the United Nations, OECD, and Indonesian education authorities. Literature selection was conducted purposively based on conceptual relevance, theoretical contribution, and alignment with the framework's core pillars. The selection process yielded a primary corpus of 20 core literature sources and policy documents, systematically structured into two main analytical categories:

1. Global Policy and Normative Frameworks (n = 10): Key international policy papers, SDG reports, and peer-reviewed articles focusing on UNESCO–SDGs, SDG 4.7, Education for Sustainable Development (ESD), Open Science, and global science education standards.
2. Local Epistemologies, Ethnoscience, and Islamic Integration (n = 10): Peer-reviewed empirical and theoretical studies focusing on Indonesian ethnoscience (*Kearifan Lokal*, *Pranata Mangsa*, vernacular architecture), Islamic integrated science values (*Tawhid*, *Khalifah*, *Maslahah*), educational technology mediation, and epistemic justice frameworks.

The review considered literature published primarily from 2006 to 2026, while earlier seminal works were retained where they provided foundational theoretical perspectives. The analysis involved thematic interpretation and comparative conceptual analysis. Thematic interpretation was used to identify recurring concepts, assumptions, and arguments concerning technology-based science education, epistemic justice, local ethnoscience, Islamic integrated science, and global sustainability agendas. Comparative conceptual analysis was then used to examine convergences, tensions, and gaps across global, local, and Islamic epistemological perspectives. Attention was given to how knowledge is represented, whose knowledge is legitimized, how technology mediates access to knowledge, and how global educational standards can be reconciled with culturally and contextually grounded perspectives.

The findings from the literature analysis were subsequently synthesized through conceptual integration. This process involved positioning the UNESCO–SDGs agenda as a global normative orientation, Islamic values as an ethical and integrative foundation, local ethnoscience as a contextual epistemological resource, and educational technology as a mediating mechanism for connecting diverse knowledge systems. The resulting synthesis informed the development of the proposed Glocal Science Education framework, which is intended as a conceptual foundation for future empirical research and curriculum development rather than as an empirically validated model.

FINDING AND DISCUSSION

Philosophical and Epistemological Foundations

Reconstructing technology-based science learning in Indonesia requires a philosophical and theoretical foundation capable of explaining the relationship between global policies, national educational practices, local epistemological traditions, and Islamic values (Biesta, 2015; Apple, 2019). The conceptual analysis indicates that reconstruction should not be limited to adding digital technologies or local cultural content to existing curricula. Rather, it requires reconsidering how knowledge is selected, represented, mediated, and legitimized in science learning. Within this perspective, UNESCO–SDGs provide a global normative orientation, local ethnoscience provides contextual epistemological resources, Islamic values provide an ethical and integrative foundation, and educational technology mediates interactions among these dimensions.

The UNESCO–SDGs global education policy is philosophically rooted in humanistic and progressivist perspectives that view education as a means of holistic and sustainable human development (Dewey, 1938; Nussbaum, 2011). Science education is therefore not merely a process of transferring scientific knowledge, but a process of developing cognitive, affective, social, ethical, and ecological capacities (Biesta, 2015; Sterling, 2010). This orientation is consistent with Education for Sustainable Development (ESD), which emphasizes critical thinking, social responsibility, environmental awareness, and learners' capacity to participate in addressing sustainability challenges (UNESCO, 2017). Quality education within SDG 4 is consequently positioned as an important foundation for achieving broader sustainable development goals (United Nations, 2015).

However, the universal orientation of global education agendas can generate tensions when implemented across highly diverse educational contexts. In Indonesia, geographical, cultural, and institutional diversity produces substantially different educational conditions (Marginson, 2016). The adoption of global standards may unintentionally privilege standardized forms of scientific knowledge while marginalizing knowledge developed through local environmental experiences and community practices (Santos, 2014; Andreotti, 2011). From a critical educational perspective, policy is not a neutral technocratic instrument but is also shaped by relations of power and knowledge (Apple, 2019; Giroux, 2011). Consequently, technology-based science education should not be interpreted simply as an obligation to adopt digital technologies, STEM–STEAM approaches, or project-based learning, but should also involve critical consideration of whose knowledge is represented and whose knowledge is legitimized.

This issue can be examined through the concept of epistemic justice (Fricker, 2007). In science education, epistemic justice involves equitable opportunities to access, interpret, produce, and validate knowledge. Two dimensions are particularly relevant. The epistemic representational gap concerns the unequal visibility of knowledge systems in curriculum and pedagogy, where formal scientific knowledge may dominate while local ecological knowledge and community-based practices receive limited recognition (Aikenhead, 2006; Santos, 2014). The epistemic access gap concerns unequal opportunities to access and participate in technology-mediated knowledge due to differences in infrastructure, teacher competence, connectivity, and institutional capacity (Selwyn, 2016; OECD, 2020). These gaps demonstrate that technology alone cannot guarantee epistemic justice.

The Indonesian context also requires consideration of Islamic perspectives on science and knowledge. Research in Indonesian Islamic schools indicates that science–religion integration can enable students to connect scientific understanding with broader religious and ethical considerations (Sahil et al., 2024). Similarly, Indonesian scholarship has conceptualized Islamic science education through the integration of Islam, science, humanities, and Indonesian contexts rather than treating these domains as separate entities (Muttaqin, 2018). Islamic values can therefore function as an ethical and worldview-oriented foundation for science education, encouraging responsible engagement with knowledge, human–nature relationships, and the consequences of scientific and technological practices (Al-Hidabi & Aljaji, 2020). Importantly, Islamic integration should not be reduced to attaching religious texts to scientific topics; rather, it provides an ethical perspective for considering why scientific knowledge is pursued and how it should be used.

This ethical and epistemological orientation can also be grounded in the Qur'anic perspective on knowledge and reflection on natural phenomena. As stated in Surah Āli 'Imrān (3:190–191):

إِنَّ فِي خَلْقِ السَّمَاوَاتِ وَالْأَرْضِ وَاخْتِلَافِ اللَّيْلِ وَالنَّهَارِ لَآيَاتٍ لِّأُولِي الْأَلْبَابِ ۝ الَّذِينَ يَذْكُرُونَ اللَّهَ قِيَامًا وَقُعُودًا وَعَلَىٰ جُنُوبِهِمْ وَيَتَفَكَّرُونَ فِي خَلْقِ السَّمَاوَاتِ وَالْأَرْضِ رَبَّنَا مَا خَلَقْتَ هَٰذَا بَاطِلًا سُبْحَانَكَ فَقِنَا عَذَابَ النَّارِ

"Indeed, in the creation of the heavens and the earth and the alternation of the night and the day are signs for people of understanding—those who remember Allah while standing, sitting, and lying on their sides, and reflect on the creation of the heavens and the earth…" (The Qur'an, Surah Āli 'Imrān, 3:190–191).

Within the context of science education, these verses provide an ethical and epistemological orientation that values observation, contemplation, and critical reflection on natural phenomena. The Qur'anic perspective does not replace empirical scientific inquiry; rather, it situates the investigation of nature within a broader framework of reflection, meaning, and human responsibility. This orientation is particularly relevant to the proposed framework because local ethnoscience is often rooted in sustained observation of environmental phenomena, while science education provides conceptual and empirical tools for critically examining such observations. Thus, the integration of Islamic values can strengthen the relationship between scientific inquiry, local knowledge, and ethical reflection without conflating religious and scientific modes of explanation.

Technology, Ethnoscience, and Islamic Values in Science Education

Educational technology is conceptualized in this study as an epistemic mediator rather than merely an instructional delivery mechanism. Its contribution involves at least four interconnected functions: documenting, representing, comparing, and producing knowledge. Digital devices can enable students to document local environmental practices through photographs, videos, interviews, and digital field notes; represent these practices through digital maps, timelines, infographics, and virtual exhibitions; compare local explanations with scientific models and empirical data; and ultimately produce and communicate evidence-based digital knowledge products. In this configuration, technology becomes meaningful not because students use digital devices, but because digital tools expand their capacity to participate in knowledge production (Selwyn, 2016; UNESCO, 2021).

Concrete Indonesian ethnoscience provides an appropriate context for operationalizing this approach. One example is Pranata Mangsa, a Javanese traditional calendrical system used to interpret seasonal patterns and guide agricultural activities. The system incorporates observations of seasonal, astronomical, climatic, and ecological indicators and has been examined through an ethnoscientific perspective (Nabila & Wirawan, 2024). In a secondary-school science unit on climate change, ecosystems, or Earth–Sun relationships, students could digitally reconstruct a local Pranata Mangsa calendar using historical rainfall and temperature data. They could compare community observations of seasonal change with meteorological datasets, visualize patterns through digital timelines or GIS-based maps, and evaluate similarities and differences between traditional indicators and contemporary scientific measurements. The objective is not to establish that traditional knowledge is scientifically equivalent to modern meteorology, but to recognize it as a meaningful starting point for scientific inquiry and epistemic dialogue.

A second example is the Bayan traditional house in Lombok, which demonstrates local knowledge embedded in traditional construction practices. Research identifies the use of local materials and traditional wooden joining techniques, including nail-free construction, with implications for structural resilience and adaptation to environmental conditions (Sariadi et al., 2023). In a secondary-school science unit on forces, material properties, structural stability, or disaster mitigation, students could use photographs, video documentation, 360-degree virtual representations, or simple 3D modelling to investigate the structural principles of the house. Digital or physical models could then be used to simulate lateral forces and compare the stability of different structural configurations. Through this process, local construction knowledge becomes a starting point for investigating formal scientific concepts rather than merely serving as cultural decoration.

The integration of Islamic values can occur within these technology-mediated activities as an ethical and reflective dimension. In the Pranata Mangsa example, students can examine seasonal and agricultural knowledge while reflecting on responsible environmental management and human responsibility toward natural resources. In the Bayan architecture example, students can investigate structural resilience, material efficiency, and environmental adaptation while considering ethical responsibilities related to human safety, resource use, and environmental stewardship. Values such as amanah (responsibility), khalifah (human responsibility for stewardship), and justice can provide an ethical lens for interpreting the purposes and consequences of scientific and technological practices. Such integration is consistent with Islamic perspectives that view science education as involving not only scientific understanding but also ethical responsibility (Al-Hidabi & Aljaji, 2020; Muttaqin, 2018).

The combination of technology, ethnoscience, and Islamic values therefore creates a more substantive form of epistemic integration. Local communities are not positioned merely as sources of cultural examples, while students are not merely consumers of digitally delivered scientific information. Instead, students can investigate local knowledge, examine evidence, compare knowledge claims, reflect on ethical implications, and produce digital representations of their findings. Ethical considerations are also necessary when digitizing community knowledge, including appropriate attribution, contextual interpretation, respect for community ownership, and avoidance of decontextualization. Technology consequently functions as a mediator of epistemic participation rather than simply a symbol of educational modernization.

Conceptual Synthesis: Toward a Glocal Science Education Framework

The conceptual synthesis indicates that the central challenge in technology-based sustainability-oriented science education is not simply technological availability, but the epistemological relationship among global standards, local knowledge, Islamic values, and digital participation. The dominant model may position global scientific knowledge as the primary source of legitimate knowledge, technology as a delivery mechanism, and students as consumers of standardized content. Such a configuration risks reproducing both epistemic representational and epistemic access gaps.

The proposed reconstruction is therefore based on four complementary principles. First, global–local epistemological hybridization requires UNESCO–SDGs and ESD principles to be critically interpreted through Indonesian socio-cultural and ecological contexts rather than adopted as culturally neutral prescriptions (Andreotti, 2011; Santos, 2014). Second, Islamic ethical integration positions Islamic values as an ethical and worldview-oriented foundation for responsible engagement with science, technology, society, and the environment (Al-Hidabi & Aljaji, 2020; Muttaqin, 2018; Sahil et al., 2024). Third, epistemic justice requires learners and local communities to be recognized not merely as recipients of scientific knowledge but as participants in knowledge interpretation and production (Fricker, 2007). Fourth, technology as epistemic mediation requires digital tools to document, represent, compare, and produce knowledge rather than merely deliver standardized content.

These principles establish the conceptual logic of the proposed Glocal Science Education framework. UNESCO–SDGs provide the global normative direction; local ethnoscience provides contextual epistemological resources; Islamic values provide ethical and worldview-oriented grounding; and educational technology provides the mediating infrastructure for knowledge interaction and production. Epistemic justice functions as the overarching principle governing how these components are represented and connected.

DOI: https://doi.org/10.30762/ijise.v5i2.8759

The framework consequently shifts technology-based science education from a model of global knowledge transmission toward dialogical, ethical, contextualized, and digitally mediated knowledge participation. Through this approach, students engage with global scientific concepts while investigating local knowledge, critically comparing different forms of evidence, reflecting on ethical dimensions through Islamic values, and producing digital knowledge products. The framework does not assume that local, religious, and scientific knowledge possess identical epistemic status. Instead, it establishes a structured space for critical dialogue in which different knowledge systems can be examined according to their contexts, evidence, meanings, and purposes. This provides a basis for science education that remains globally oriented while becoming more contextually grounded, culturally responsive, ethically informed, technologically meaningful, and epistemically just.

Conceptual Framework of Glocal (Global-Local) Science Education: UNESCO-SDGs aligned & rooted in local knowledge

The following is a synthesis result in the form of a visual framework for technology-based science learning that is glocal (global-local) as shown **Figure 1**. This model is designed to systematically demonstrate the main components, relationships between components, workflows, and outputs of the reconstruction of science learning oriented toward epistemic justice.

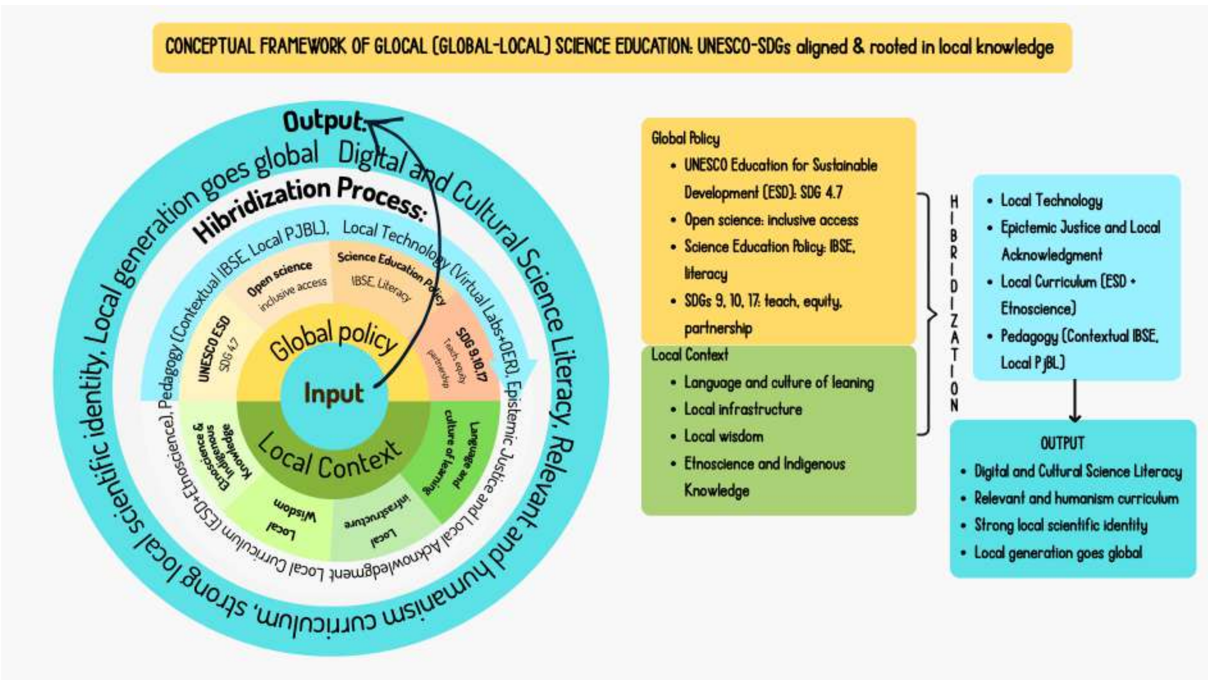

Figure 1. Conceptual Framework of Glocal (Global-Local) Science Education: UNESCO-SDGs aligned & rooted in local knowledge

DOI: https://doi.org/10.30762/ijise.v5i2.8759

General Description of the Model

The proposed model is the Conceptual Framework of Global Science Education, a technology-based science learning framework that aligns with UNESCO-SDGs policies and is deeply rooted in the local Indonesian context. This model visualizes science learning as an open system built on the principle of "Think Globally, Teach Science Locally," which is positioned as the core orientation of the entire framework. This core principle emphasizes that global goals of science education, such as sustainability, inclusivity, and social responsibility, can only be meaningfully achieved if the learning process is designed and implemented through the local context of learners. Structurally, this model is composed of four main elements, namely: (1) glocal core orientation, (2) global policy layer, (3) local context layer, and (4) the process of epistemological hybridization. These four elements interact dynamically to produce equitable and relevant science learning outcomes. The circular model in this framework demonstrates that the science education process is ongoing.

Core Orientation: Think Globally – Teach Science Locally

The model's core orientation places the Think Globally – Teach Science Locally principle at the center of the framework. This principle serves as an epistemological and pedagogical guide, ensuring that science learning does not become trapped in a global-versus-local dichotomy. Global issues and goals (e.g., the SDGs, sustainability, and global scientific literacy) serve as the normative horizon, while the local context serves as the primary starting point for curriculum design, pedagogy, and technology use. This core orientation ties all components of the model together within a unified vision of reconstructing science learning that is contextual and transformative.

Global Policy Layer

The global policy layer represents the international normative framework that serves as a reference for reconstructing science learning. This layer includes several key components, namely:

1. UNESCO Education for Sustainable Development (ESD), especially SDG 4.7, which emphasizes inclusive, sustainable education and is oriented towards the formation of responsible global citizens.
2. Open Science, which affirms the principles of open access, collaboration, and democratization of scientific knowledge.
3. Science Education Policy, including Inquiry-Based Science Education (IBSE) as well as strengthening science literacy and digital literacy.
4. SDGs 9, 10, and 17, which emphasize innovation, equity, and global partnerships.

DOI: https://doi.org/10.30762/ijise.v5i2.8759

In this model, global policies are not positioned as top-down technocratic instructions, but rather as ethical frameworks and macro goals that provide general direction for technology-based science learning.

Local Context Layer (Local Context Layer)

The local context layer describes the epistemological, social, and cultural realities of Indonesia that serve as the operational foundation for science learning. The main components of this layer include:

1. Local learning language and culture, which influence how students understand and interpret science concepts.
2. Local infrastructure, including technology availability, laboratory facilities, and digital access.
3. Local wisdom, ethnoscience, and indigenous knowledge that live in community practices.

This layer emphasizes that science learning does not occur in a vacuum, but is always embedded in a specific socio-cultural context. Therefore, local contexts are treated as legitimate epistemic resources, not simply as learning settings.

The Process of Epistemological Hybridization

The operational core of the model lies in the process of epistemological hybridization, which serves as an integration mechanism between global policies and local contexts. This process is realized through four main components:

1. Local curriculum, which integrates ESD with ethnoscience and community-based sustainability issues.
2. Contextual pedagogy, such as contextual IBSE and local problem-based Project-Based Learning (PjBL).
3. Local and open technologies, including virtual laboratories, Open Educational Resources (OER), and inclusively accessible digital learning platforms.
4. Epistemic justice and recognition of local knowledge, which ensures that local knowledge is not marginalized in learning processes and digital representations.

This hybridization process allows for an equal epistemological dialogue between global and local knowledge, and prevents the dominance of one source of knowledge over another.

Model Workflow

Operationally, the model works through the following flow: global policies and local contexts become the initial input → are brought together through a process of epistemological hybridization → are implemented in the curriculum, pedagogy, and learning technology → produce equitable and relevant science learning outcomes. This flow is cyclical and reflective,

DOI: https://doi.org/10.30762/ijise.v5i2.8759

allowing for continuous evaluation and refinement in accordance with the dynamics of the local context and global policy developments.

Model Output

The main outputs of this model include:

1. Digital and Cultural Science Literacy, namely science literacy integrated with digital literacy and cultural understanding.
2. A relevant and humanistic science curriculum, aligned with sustainability issues and local needs.
3. A strong local scientific identity, where learners see themselves as part of a global knowledge community without losing their local roots.
4. A local generation capable of participating in global networks, through SDG-based partnerships and collaborations.

Systemic Model of Technology-Based Science Learning Reconstruction

After formulating the epistemological framework for reconstructing science learning through the global-local hybridization circle model, the next step is to explain how this framework is operationalized in the education system. Therefore, this study presents a Systemic Model of Science Learning Reconstruction, visualized in the Conceptual Analysis of Science Learning as shown **Figure 2**.

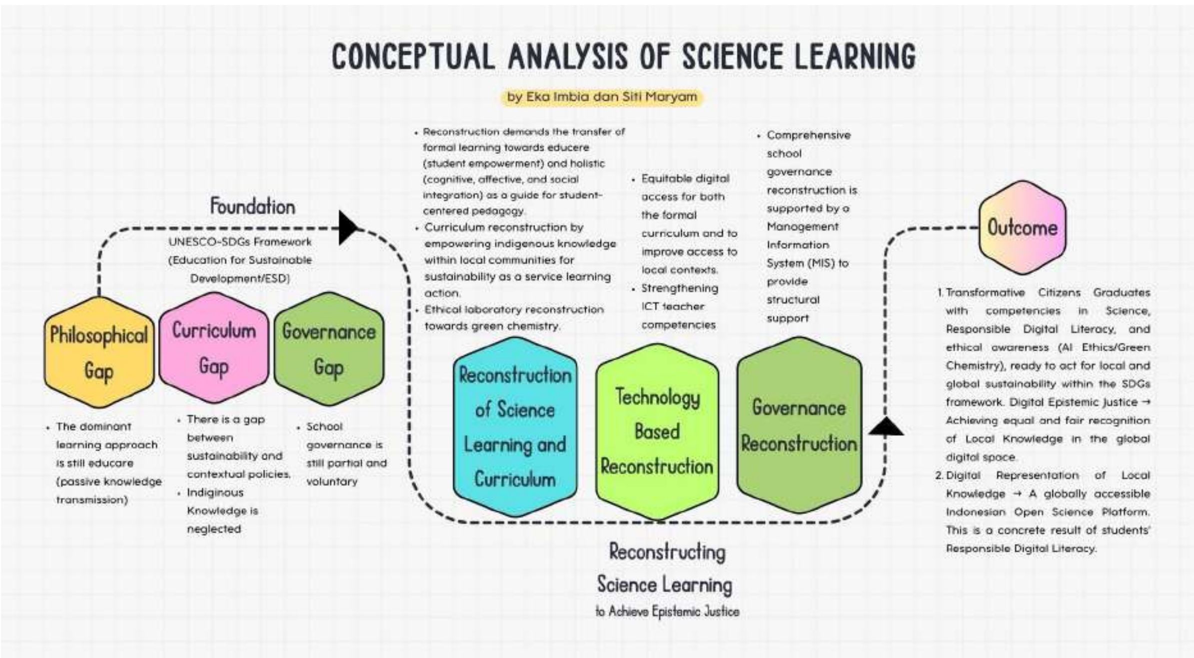

Figure 2. Conceptual Analysis of Science Learning

This model serves to map the structural and institutional transformation of science learning, from identifying fundamental gaps to achieving desired learning outcomes. This systemic model emphasizes the process and mechanisms of change, thus addressing the question of how the principles of epistemological hybridization and epistemic justice are realized in curriculum practices, technology utilization, and science education governance.

Identifying Gaps in Science Learning

The initial stage of the systemic model identifies three structural gaps hindering sustainability-based science learning, namely philosophical, curriculum, and governance gaps. The philosophical gap is marked by the dominance of an educare approach that positions students as passive recipients of knowledge, contrasting with ESD principles that emphasize empowerment and critical engagement. The curriculum gap is reflected in the limited integration of local contexts, sustainability issues, and indigenous knowledge within science education. Meanwhile, the governance gap relates to weak institutional support, resulting in fragmented and teacher-dependent implementation of ESD. Collectively, these gaps indicate that improving science learning requires not only pedagogical innovation but also systemic reconstruction that integrates epistemological, curricular, and institutional transformation.

Science Learning Reconstruction Process

In response to these gaps, this model proposes three main, interconnected reconstruction components: Reconstruction of Science Learning and Curriculum, Technology-Based Reconstruction, and Governance Reconstruction. Learning and curriculum reconstruction emphasise a shift from content-oriented learning to holistic and contextual learning, integrating global and local knowledge through a transformative pedagogical approach. Technology-based reconstruction positions digital technology as a means to expand access to learning, enhance the representation of local knowledge, and support collaborative and reflective learning. Governance reconstruction addresses the structural weakness that historically relegates glocal science initiatives to short-lived, voluntary teacher efforts. Rather than relying on individual teacher enthusiasm, this framework uses Educational Management Information Systems (MIS) as an institutional vehicle across two policy tiers:

1. School-Level Institutionalization: School-based MIS platforms embed glocal science modules directly into standard curriculum planning repositories (*Kurikulum Merdeka*) and digital lesson plan banks. By mapping local ethnoscience units and Islamic integrated science indicators directly into digital MIS teacher evaluation portals, school leadership transforms glocal projects from discretionary activities into recognized, credit-bearing instructional standards.
2. Regional & District Policy Governance: District Education Offices (*Dinas Pendidikan*) utilize centralized MIS databases to store, peer-review, and distribute validated, digitally

mediated ethnoscience modules across regional networks. By establishing formal regional performance metrics within MIS monitoring systems—such as tracking school engagement with regional environmental issues and local knowledge documentation—district policy converts isolated classroom trials into institutionalized, district-wide quality benchmarks.

Reconstruction Outputs and Learning Implications

The final stage in this systemic model is the achievement of learning outcomes oriented toward epistemic justice. These outcomes include the formation of students as critical global citizens, possessing scientific and digital literacy, and being able to link local and global issues within a sustainability framework. Furthermore, this model increases the visibility and legitimacy of local knowledge in science learning spaces, both through the formal curriculum and digital representations. Thus, the Conceptual Analysis of Science Learning serves as an operational bridge connecting the epistemological principles of the circular model with the actual practice of reconstructing technology-based science learning. This model emphasises that achieving epistemic justice depends not only on pedagogical intent but also on the systemic integration between educational philosophy, curriculum design, technology utilisation, and institutional governance.

Epistemological Foundations of UNESCO–SDGs Policy and Policy Critique and Implications for Technology-Based Science Curriculum and Learning in Indonesia

Literature analysis demonstrates that UNESCO–SDGs policies (specifically SDG 4.7 and Education for Sustainable Development) provide a strong epistemological base grounded in a transformative educational paradigm. UNESCO articulates education as forming a complete subject—encompassing cognitive, affective, social, ethical, and action dimensions (UNESCO, 2017, 2020). The shift from *educare* (passive transmission) to *educere* (leading out/empowering) positions learners as active agents of social and environmental change (Sari et al., 2025).

In Indonesia, however, the policy translation of UNESCO–SDGs has often remained administrative and technocratic. While concepts such as *sustainability* and *21st-century skills* appear in national policy documents, curriculum implementation and assessment frameworks are still dominated by content memorization and standardized testing. Educational technology is frequently restricted to material delivery mechanisms (e.g., slide presentations, e-learning platforms) rather than serving as a transformative medium for critical exploration and knowledge production (Majid & Fuada, 2020). From an epistemic justice perspective, this reductionist approach risks reproducing educational inequality by framing students as passive consumers of external knowledge while marginalizing local ways of knowing (Fricker, 2007; Chowdhury & Chowdhury, 2024).

Addressing these policy tensions requires synthesizing global mandates and local ethnoscience with Islamic epistemological principles, specifically through the Qur'anic framework of *Ayat Kauniyah* (signs of God embedded in natural phenomena). Within this integrative paradigm, the physical universe (*al-'ālam*) is not merely a neutral object for resource exploitation, but a living domain of divine signs requiring empirical investigation, reflection, and responsible stewardship.

Theological and Epistemological Anchor: Ayat Kauniyah in Glocal Science

The integration of local ethnoscience and global sustainability within the proposed framework is explicitly anchored in three fundamental Qur'anic concepts:

Empirical Observation and Inquiry (*IBSE*)

The framework's emphasis on Inquiry-Based Science Education (IBSE) rooted in immediate, local contexts aligns directly with the Qur'anic directive to observe local ecological, physical, and geological phenomena:

أَفَلَا يَنظُرُونَ إِلَى الْإِبِلِ كَيْفَ خُلِقَتْ ۝ وَإِلَى السَّمَاءِ كَيْفَ رُفِعَتْ ۝ وَإِلَى الْجِبَالِ كَيْفَ نُصِبَتْ ۝ وَإِلَى الْأَرْضِ كَيْفَ سُطِحَتْ

"Do they not look at the camels, how they are created? And at the sky, how it is raised? And at the mountains, how they are erected? And at the earth, how it is spread out?" (Surah Al-Ghasyiyah, 88:17–20).

This verse provides both a theological and methodological justification for investigating local contexts—such as indigenous agricultural calendars (*Pranata Mangsa*) or vernacular architecture (*Bayan* construction). Science education is directed to begin not with abstract, decontextualized formulas, but with direct, empirical reflection on the surrounding physical environment.

2. Ecological Balance and Sustainability (*Mīzān*)

The alignment between UNESCO–SDGs sustainability mandates and Islamic environmental ethics is grounded in the principle of *Mīzān* (cosmic and ecological balance):

وَالسَّمَاءَ رَفَعَهَا وَوَضَعَ الْمِيزَانَ ۝ أَلَّا تَطْغَوْا فِي الْمِيزَانِ ۝ وَأَقِيمُوا الْوَزْنَ بِالْقِسْطِ وَلَا تُخْسِرُوا الْمِيزَانَ

"And the heaven He raised and imposed the balance, that you not transgress within the balance. And establish weight in justice and do not make deficient the balance." (Surah Ar-Rahman, 55:7–9).

In the context of climate change and environmental degradation, *Mīzān* establishes a strict ethical imperative against ecological disruption (*tatghaw fil-mīzān*). Technology and scientific inquiry are deployed not to dominate nature, but to measure, monitor, and restore environmental equilibrium in service of public interest (*Maslahah*).

3. Intercultural Dialogue and Epistemic Justice (*Ta'ārof*)

The hybridization of global scientific standards and diverse local epistemologies reflects the principle of mutual recognition and dialogue:

...يَا أَيُّهَا النَّاسُ إِنَّا خَلَقْنَاكُم مِّن ذَكَرٍ وَأُنثَىٰ وَجَعَلْنَاكُمْ شُعُوبًا وَقَبَائِلَ لِتَعَارَفُوا

"O mankind, indeed We have created you from male and female and made you peoples and tribes that you may know one another…" (Surah Al-Hujurat, 49:13).

Applied to science education, *Ta'ārof* demands epistemic justice (*lita'ārafū*). Global scientific agendas should not act as a totalizing hegemony that erases local knowledge systems; rather, global science and indigenous ethnoscience must enter into a respectful, equitable dialogue, recognizing local wisdom as a contextually rich contribution to global sustainability solutions.

Epistemological Foundations of the Indonesian Local Context and Their Implications for Technology-Based Science Curriculum and Learning

The epistemological foundations of the local Indonesian context are rooted in socio-cultural diversity, ethnoscientific practices, and communal, contextual human-nature relations. In various local communities across Indonesia, knowledge regarding nature, food, health, and the environment is not built solely through theoretical abstraction, but through repeated practice, long-term observation, and direct interaction with the local ecological environment. Literature demonstrates that practices such as local agriculture, traditional food fermentation, natural resource management, and community-based healthcare contain contextual and empirical scientific logic, although not always articulated in the formal language of modern Western science (Wennersten et al., 2023; Amorim et al., 2025). From an Education for Sustainable Development (ESD) and Islamic integrated perspective, this form of knowledge holds profound epistemic relevance because it naturally unifies ecological, social, empirical, and ethical dimensions into everyday life practices.

From an Islamic epistemological standpoint, these indigenous practices represent an authentic operationalization of observing *Ayat Kauniyah* (the divine signs manifested in the natural world). The Qur'anic worldview explicitly commands empirical reflection on immediate, localized ecosystems (*al-'ālam*), framing human interaction with nature as an act of both scientific discovery and spiritual awareness (*Tadabbur*). Local wisdom (*Kearifan Lokal*) is thus not merely an empirical survival strategy, but a contextually developed reflection of human stewardship (*Khalifah*) and cosmic balance (*Mīzān*). By recognizing these local observational practices as legitimate forms of knowledge, science education honors the holistic unity of knowledge (*Tawhid*), where empirical investigation and spiritual/ethical values complement rather than contradict one another.

However, the formal education system in Indonesia tends to marginalize local and Islamically grounded knowledge from the mainstream of science learning. Local knowledge is often reduced to mere contextual illustrations or additional cultural ornament, rather than being treated as a legitimate epistemic resource in the construction of scientific concepts. The formal science curriculum still positions modern Western science as the sole authoritative epistemological reference, treated as neutral, objective, and universal. This condition reflects what Santos (2014) conceptualizes as *epistemicide*—the systematic erasure or delegitimization of non-dominant knowledge systems through institutional non-recognition. In this context, science education contributes to the reproduction of a strict hierarchy of knowledge, in which ways of knowing rooted in local community practices and Islamic value systems are deemed inferior, subjective, or unscientific.

The epistemological implication of this marginalization is structural epistemic injustice. According to Fricker (2007), epistemic injustice occurs when individuals or groups are not fairly recognized as subjects of knowledge (*knowers*). In science learning in Indonesia, students from communities rich in ethno-ecological and Islamic tradition often lack the pedagogical space to represent, reflect on, and validate their existing worldviews. As a result, science learning creates a severe disconnect between students' lived cultural/religious experiences and the secularized scientific knowledge taught in schools. This epistemic rift diminishes the meaning, personal relevance, and transformative power of science education, stripping scientific practice of its moral purpose (*Maslahah*) and personal purification/growth (*Tazkiyah*).

In the context of technology-based science learning, this epistemic injustice is further exacerbated by the underrepresentation of local and indigenous knowledge within the global digital education ecosystem. Online learning platforms, Open Educational Resources (OER), and global Open Science initiatives remain heavily dominated by content produced in developed Western nations and grounded in secularized epistemologies (Chowdhury & Chowdhury, 2024). Limited critical digital literacy, low local content production capacity, and uneven technological infrastructure result in Indonesia's rich ethno-scientific and Islamic knowledge being underdocumented and virtually invisible in the global digital space. Technology, which should theoretically serve as a democratic medium for knowledge production, risks reinforcing digital colonialism and epistemic inequality if it is not designed contextually, ethically, and inclusively.

Consequently, the reconstruction of technology-based science learning in Indonesia must begin with an explicit epistemological recognition of the local Indonesian context and Islamic ethical principles as foundational sources of knowledge, rather than mere instructional settings. The theoretical implication for curriculum reform is the urgent need to reposition local ethnoscience and Islamic values as integral structural components of the science curriculum. Formal scientific concepts (e.g., thermodynamics, ecosystem dynamics, microbiology) should be systematically developed through dynamic dialogue with relevant local practices and ethical framework principles:

1. Tawhid (Unity of Knowledge): Dissolves the artificial divide between scientific inquiry and moral/spiritual purpose, framing the study of natural laws as an exploration of divine order.
2. Khalifah (Vicegerency & Environmental Stewardship): Redefines the learner's identity from a passive consumer of information or exploiter of resources to an active, responsible guardian of the Earth.
3. Maslahah (Public Interest & Ecological Well-being): Serves as the primary criterion for evaluating scientific applications, ensuring technology is utilized to solve community challenges and preserve ecological integrity.
4. Tazkiyah (Ethical and Spiritual Elevation): Ensures that scientific literacy fosters humility, intellectual integrity, and social responsibility within the learner.

Within this reconstructed curriculum framework, educational technology is re-envisioned as an epistemic mediator for the digital representation, documentation, and validation of local and faith-anchored knowledge. Various innovative pedagogical approaches can be integrated, such as:

1. Context-Based Virtual Laboratories: Simulating local ecological phenomena and traditional technologies (e.g., earthquake-resistant vernacular architecture, traditional fermentation) alongside modern physics and chemistry models.
2. Citizen Science Projects: Engaging students and local communities in collecting environmental data via digital tools, enabling them to monitor ecological balance (*Mīzān*) and address local pollution or climate challenges.
3. Local Issue-Based Project Learning (PjBL): Empowering students to investigate community-based problems through digital media, producing open-access digital scientific artifacts that serve the public good (*Maslahah*).

Through these technology-mediated approaches, digital tools serve not only as instructional media, but as strategic instruments for strengthening local epistemic identities, honoring divine signs in nature (*Ayat Kauniyah*), and expanding community participation in sustainable knowledge production. Without a strong local and Islamic epistemological foundation, integrating technology into science learning risks widening both the digital and epistemic divides. Conversely, when technology is designed and implemented based on the recognition of local epistemological diversity and Islamic ethics, technology-based science learning becomes a transformative catalyst for realizing epistemic justice, elevating educational relevance, and fulfilling sustainable development goals within the Indonesian context.

CONCLUSION

This study develops a conceptual framework of Glocal (Global–Local) Science Education for reconstructing technology-based science learning in Indonesia, positioning epistemic justice as its primary guiding principle. The framework demonstrates that persistent foundational gaps in educational philosophy, curriculum design, transformative pedagogy, and digital equity can be effectively bridged through an epistemological hybridization. This process harmonizes global normative orientations from the UNESCO–SDGs agenda with local Indonesian ethnoscience as contextual learning resources, Islamic integrated science values (*Tawhid, Khalifah, Maslahah*) as an ethical and integrative foundation, and educational technology as an emancipatory epistemic mediator. Guided by the overarching mandate to *"Think Globally, Teach Science Locally,"* the proposed model connects universal sustainability imperatives with indigenous wisdom and religious ethics, shifting students from passive consumers of standardized content to active producers of contextualized scientific knowledge.

As a conceptual paper, the proposed framework serves as a theoretical architecture and has not yet undergone empirical field testing. Consequently, future research must prioritize its empirical validation, practical refinement, and pedagogical operationalization in real-world educational settings. Specifically, researchers are strongly encouraged to adopt Design-Based Research (DBR) methodologies, engaging in iterative cycles of collaborative co-design, prototyping, and classroom refinement alongside secondary school science educators. Future empirical interventions should execute pilot implementations of these glocal science units across diverse and representative Indonesian educational settings—facilitating comparative analyses between general secondary schools (*Sekolah Menengah Atas* / SMA) and Islamic secondary schools (*Madrasah*) across both well-resourced urban centers and ecologically distinct rural or coastal communities. Furthermore, future studies should construct comprehensive mixed-methods evaluation instruments to measure tangible growth in students' digital-cultural science literacy, epistemic agency, and sustainability mindsets, while investigating how district-level Educational Management Information Systems (MIS) can structurally institutionalize and scale these practices into broader regional policy governance.

Limitations of the Study

This study is a conceptual paper that develops a theoretical framework based on a structured and purposive literature review. As a result, the selection of literature is guided primarily by conceptual relevance to UNESCO–SDGs, epistemic justice, and science education, which may limit the comprehensiveness and reproducibility of source selection. The proposed Glocal Science Education framework has not yet been empirically validated and therefore should be interpreted as a theoretical proposition that requires further testing through empirical and design-based research. The discussion of Indonesian local epistemologies is also presented at a macro-conceptual level, which does not fully represent the diversity of contextual knowledge systems across regions. Furthermore, the role of educational technology is addressed from a conceptual and normative perspective without detailed examination of specific implementation contexts. Despite these limitations, the study provides a coherent conceptual synthesis that contributes to the discourse on epistemic justice and technology-based science education within the UNESCO–SDGs framework.

REFERENCES

Aikenhead, G. S. (2006). *Science education for everyday life: Evidence-based practice*. Teachers College Press.

Al-Hidabi, D. A. Y., & Aljaji, R. (2020). Aims of science education from an Islamic perspective. *IIUM Journal of Educational Studies, 8*(2), 3–26. https://doi.org/10.31436/ijes.v8i2.338

Amorim, L., Santos, C., & Timmis, K. (2025). Prioritising microbiology in secondary education addresses emerging scientific-social-educational challenges and competency needs. *Microbial Biotechnology, 18*(9), e70224. https://doi.org/10.1111/1751-7915.70224

Andreotti, V. (2011). *Actionable postcolonial theory in education*. Palgrave Macmillan. https://doi.org/10.1057/9780230337794

Apple, M. W. (2019). *Ideology and curriculum* (4th ed.). Routledge.

Biesta, G. J. J. (2015). *Good education in an age of measurement: Ethics, politics, democracy*. Routledge.

Chowdhury, G., & Chowdhury, S. (2024). Towards an agenda for information education and research for sustainable development. *Journal of Information Science*, 1–19. https://doi.org/10.1177/01655515241260711

Dewey, J. (1938). *Experience and education*. Macmillan.

Fricker, M. (2007). *Epistemic injustice: Power and the ethics of knowing*. Oxford University Press. https://doi.org/10.1093/acprof:oso/9780198237907.001.0001

García-Martín, J., & Pérez Fernández, L. M. (2026). A review of global strategies for achieving Sustainable Development Goal 4 in higher education (2020–2024): Key actions in the Education for Sustainable Development framework. *Sustainable Development, 34*(S2), 843–856. https://doi.org/10.1002/sd.70374

Giroux, H. A. (2011). *On critical pedagogy*. Bloomsbury Academic.

Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi. (2022). *Kurikulum Merdeka: Kerangka dasar kurikulum*. Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi.

Majid, N. W. A., & Fuada, S. (2020). E-learning for society: A great potential to implement education for all (EFA) movement in Indonesia. *International Journal of Interactive Mobile Technologies, 14*(2), 250–258. https://doi.org/10.3991/ijim.v14i02.11363

Marginson, S. (2016). The worldwide trend to high participation higher education: Dynamics of social stratification in inclusive systems. *Higher Education, 72*, 413–434. https://doi.org/10.1007/s10734-016-0016-x

Muttaqin, A. (2018). Konstruksi kurikulum sains Islam Keindonesiaan (integrasi Islam, sains kealaman, sains humaniora dan Keindonesiaan). *EDUKASI: Jurnal Penelitian Pendidikan Agama dan Keagamaan, 16*(1), 80–93. https://doi.org/10.32729/edukasi.v16i1.460

Nabila, K., & Wirawan, M. S. A. (2024). Sistem Pranata Mangsa: Tinjauan etnosains dan uji keakuratan data iklim tahun 2023 di Yogyakarta. *Lembaran Antropologi, 3*(1), 21–34. https://doi.org/10.22146/la.7254

Nussbaum, M. C. (2011). *Creating capabilities: The human development approach*. Harvard University Press. https://doi.org/10.4159/harvard.9780674061200

OECD. (2020). *Education responses to COVID-19: Embracing digital learning and online collaboration*. OECD Publishing. https://doi.org/10.1787/d75eb0e8-en

Purwati, N., Zubaidah, S., & Mahanal, S. (2023). Mapping basic science and religious competencies: An initial step to realizing integrated science learning with Islamic values. *Biosfer: Jurnal Pendidikan Biologi, 16*(1), 186–196. https://doi.org/10.21009/biosferjpb.30799

Sahil, J., Zubaidah, S., Corebima, A. D., Gofur, A., & Saefi, M. (2024). The practice of science and religion integration: Evidence from an Indonesian Islamic school. *JPBI (Jurnal Pendidikan Biologi Indonesia), 10*(1), 12–26. https://doi.org/10.22219/jpbi.v10i1.31020

Sanabria-Z, J., Alfaro-Ponce, B., González Peña, O. I., Terashima-Marín, H., & Ortiz-Bayliss, J. C. (2022). Engagement and social impact in tech-based citizen science initiatives for achieving the SDGs: A systematic literature review with a perspective on complex thinking. *Sustainability, 14*(17), 10978. https://doi.org/10.3390/su141710978

Santos, B. de S. (2014). *Epistemologies of the South: Justice against epistemicide*. Routledge.

Sari, T., Nayir, F., & Poyrazli, S. (2025). Educare, educere, or holistic? Exploring researchers' educational approaches in Education for Sustainable Development research. *Sustainable Development, 33*(5), 6590–6603. https://doi.org/10.1002/sd.3481

Sariadi, S., Kurnia, N., Sukarma, I. K., Herayanti, L., Habibi, H., & Azmi, I. (2023). Application of indigenous knowledge in building resilience: A case study of the construction of Bayan traditional houses in Lombok. *Hydrogen: Jurnal Kependidikan Kimia, 11*(6), 1053–1068. https://garuda.kemdiktisaintek.go.id/documents/detail/5654725

Selwyn, N. (2016). *Education and technology: Key issues and debates* (2nd ed.). Bloomsbury Academic.

Sterling, S. (2010). Learning for resilience, or the resilient learner? Towards a necessary reconciliation in a paradigm of sustainable education. *Environmental Education Research, 16*(5–6), 511–528. https://doi.org/10.1080/13504622.2010.505427

UNESCO. (2017). *Education for Sustainable Development Goals: Learning objectives*. UNESCO. https://doi.org/10.54675/CGBA9153

UNESCO. (2020). *Education for sustainable development: A roadmap*. UNESCO.

UNESCO. (2021). *Recommendation on open science*. UNESCO.

United Nations. (2015). *Transforming our world: The 2030 Agenda for Sustainable Development*. United Nations.

Wennersten, L., Wanselin, H., Wikman, S., & Lindahl, M. (2023). Interpreting students' ideas on the availability of energy and matter in food webs. *Journal of Biological Education, 57*(1), 3–23. https://doi.org/10.1080/00219266.2020.1858935