



Rethinking Education Innovation for Sustainable Development in the AI Era: A G20 Policy-Oriented Perspective

RESEARCH ARTICLES

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ABSTRACT

This position paper, developed through collaborative efforts of G20 experts, examines the transformative role of education innovation in advancing sustainable development during the AI era. It argues that AI does not independently reshape education but amplifies existing institutional structures and choices. The article addresses four core themes. First, it calls for a fundamental rethinking of education research, which is currently fragmented and contested, urging a return to foundational questions of purpose, equity, and temporality. Second, it explores the dual nature of AI in schools, acknowledging its potential for personalized learning and systemic efficiency while warning of risks like algorithmic bias, inequity, and the illusion that technology can replace educators. Third, it redefines teaching for this new context, positioning educators as designers of meaning and ethical mediators rather than mere transmitters of content, with AI literacy emerging as a critical competency. Fourth, it engages with the persistent digital divide, proposing a multidimensional policy framework for inclusive learning pathways. In the concluding section, the article frames education as a strategic steering mechanism, emphasizing that human choices—not technology alone—will determine whether AI fosters equitable, sustainable, and just futures for sustainable development.

KEYWORDS:

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INTRODUCTION

The Sustainable Development Goals (SDGs), adopted in 2015 represent the humanity's collective commitments to a more sustainable future. Yet the 2025 SDGs report delivers a sobering assessment: “only 35 percent of SDG targets are on track, nearly half are moving too slowly and, alarmingly, 18 per cent are in reverse” (United Nations, 2025, p. 2). With just five years remaining, the UN Secretary-General has called for urgent action to “shift into overdrive” (United Nations, 2025, p. 49).

In this context, education remains a powerful lever for sustainable development. International research consistently shows that education advances environmental sustainability through ecological literacy (Al-Nuaimi & Al-Ghamdi, 2022), economic sustainability through skills for decent work and innovation (Yang & Wu, 2024; Khavenson et al., 2018), and social sustainability through equity and inclusion (Tafese & Kopp, 2025). However, the rapid expansion of artificial intelligence (AI) is transforming how knowledge is produced, accessed, and applied — reshaping education systems worldwide.

This position paper originates from the G20 Education Dialogue (Beijing, 2024–2025) and has been collaboratively written by experts who participated in those discussions, aiming to examine education change for sustainable development in the AI era. It develops four key theses. First, it calls for rethinking education research through longitudinal and historically comparative methodologies to resist technological acceleration. Second, it highlights AI's dual nature—promising personalization and efficiency while risking bias, inequity, and teacher replacement. Third, it advocates for redefining teaching as formation rather than transmission, with AI literacy across developmental stages. Fourth, it proposes bridging the digital divide via five G20-aligned policy pillars. The paper also addresses epistemic justice and data sovereignty for the Global South, concluding that human choices—not technology alone—will determine whether AI fosters sustainable and just futures.

FUTURE-ORIENTED EDUCATION RESEARCH AND COLLABORATION FOR SUSTAINABLE DEVELOPMENT IN THE AI ERA: RETHINKING EDUCATION RESEARCH IN A FRAGMENTED AND CONTESTED FIELD

Education research unfolds in a moment marked by the fragmentation of knowledge, the redefinition of institutional roles, and growing disputes over the social function of education and science. Furthermore, the rapid expansion of artificial intelligence in education poses a profound challenge to how knowledge is produced, transmitted, and governed, intensifying longstanding debates about the purposes and boundaries of education research. Far from losing relevance, the question gains urgency precisely because the field itself is under pressure—epistemically, institutionally, and politically.

Education has been shaped by shifting disciplinary perspectives and powerful conceptual frameworks, ranging from ideas about the soul and moral formation to human capital, quality assurance, and evidence-based policy (Ydesen, 2025). Today, what we call “education research” is produced across a wide array of institutional sites: universities, international organizations, research institutions, policy networks, think tanks, consultancies, and, increasingly, private corporations with their own research units. This makes definition of education research ambiguous and contested.

This fragmentation is not merely methodological but also addresses issues such as who defines education, which problems matter, and which futures are desirable. In recent years global policy brokers, technology, and economic organizations have acquired unprecedented influence over educational agendas (Edwards et al., 2024). This raised questions about the autonomy of education as a field of knowledge, and the capacity of research to sustain critical, unbiased, and socially oriented perspectives.

In this context, future-oriented education research cannot simply expand its agenda indefinitely. Rather, it must ask how to navigate this “exploded” landscape without losing coherence. One productive way to do so is to return to a set of basic but powerful questions—Who? What? For whom? How? And for what purpose?—and apply them to educational processes and

research. These questions do not reduce complexity, but help reorienting the inquiry to ethical and political stakes. The following subsections offer a reflection on three core questions of education—educating, teaching, and schooling—revisited through historical and transnational perspectives in order to illuminate the challenges that future-oriented education research must confront in the context of sustainable development and the AI era.

EDUCATING AND TEACHING IN THE AI ERA: TIME, EQUALITY, AND PROFESSIONAL KNOWLEDGE

A renewed research agenda must reengage the concept of education as a foundational human practice, intergenerational transmission that precedes and exceeds formal schooling. Through education, human beings become subjects of language, culture, and social life. Only a small portion of this process has historically been institutionalised within school systems (Tröhler, 2013). Reclaiming this broader understanding is crucial since education is increasingly reduced to measurable outputs or short-term outcomes.

Within this reengagement time is recognized as a key analytical category. Educational processes unfold across multiple temporalities—biographical, institutional, historical, and affective—that cannot be reduced to policy cycles or performance metrics (Steiner-Khamisi, 2025). However, contemporary educational reforms, often neglect these temporal dimensions. Research that takes time seriously can resist the acceleration that characterises both policy discourse and technological development, restoring depth and density to educational analysis. Longitudinal designs that track cohorts of learners and educators over 5–10 years can capture how AI-mediated learning interacts with developmental trajectories, shifting institutional contexts, and evolving AI capabilities. Such historical-comparative methods help examine how previous technological reforms (computers, internet) played out over decades, identifying recurring patterns of adoption and unintended consequences.

Equally important is the problem of inequality. Educational inequalities are not anomalies but structural features of educational systems. They are continuously produced and reproduced through policies, practices, and representations, often under the banner of inclusion or innovation. Addressing inequality today requires examining the construction of differences within educational arrangements, including through new digital and algorithmic tools.

The growing presence of AI in education has been accompanied by narratives that reframe deeply social problems as technical challenges, promising efficiency and personalization while leaving structural inequalities intact or potentially intensifying them. This dynamic has profound implications for teaching.

Teaching risks being reduced to a set of automatable tasks—planning, assessment, and feedback—rather than as a situated, relational, and ethical practice. Such developments contribute to the de-professionalization of teachers, positioning technology as something educators must adapt to rather than as something shaped by pedagogical knowledge. This was first witnessed in the growth of e-learning opportunities and in education reforms such as neo-liberal school choice (Barbour, 2017; Horn & Staker, 2015; Moe & Chubb, 2009; Stalker & Horn, 2012). Therefore, education research must interrogate what is being automated, whose expertise informs technological design, and what visions of teaching and learning are embedded in AI systems.

These questions take on additional weight across G20 countries where AI is promoted as a driver of innovation and competitiveness, yet its educational deployment reflects existing asymmetries of economic and technological development. Hence future-oriented education research must address the divergent trajectories and ensure that technological innovation does not reinforce global educational inequalities.

SCHOOLING, GOVERNANCE, AND TRANSNATIONAL PERSPECTIVES ON THE FUTURE

The third axis of a future-oriented research agenda concerns schooling as an institutional and political project. Contemporary education systems operate within a global context marked by multiple, overlapping crises: armed conflicts, shifting political orders, ecological degradation, and declining public trust in institutions. These dynamics directly affect education, challenging long-standing assumptions about compulsory schooling, state responsibility, and the public value of education.

In many contexts, the language that historically underpinned schooling—rights, obligations, justice, citizenship, and the role of the state—is increasingly contested. Debates over parental responsibility, individual freedom, and state intervention reflect broader ideological shifts that place education at the centre of political struggle. Research on schooling must therefore address these tensions, recognising that within education shared values are negotiated rather than merely implemented.

At the same time, schooling is embedded within a global educational architecture that has evolved since the mid-twentieth century. International organizations, development agencies, NGOs, and private actors play a significant role in shaping educational agendas, financing reforms, and defining indicators of success. The Sustainable Development Goals—particularly SDG 4—embody both the promise and the contradictions of this architecture (Edwards, Asadullah & Webb, 2024). They articulate ambitious commitments to inclusion and quality, yet also expose fragmentation, competition, and divergent visions of education.

For G20 members, this transnational dimension is particularly significant. The G20 serves as a key forum where global educational expectations are articulated, often through policy coordination, benchmarking, and shared narratives about the future of skills and learning. A future-oriented research agenda must adopt a critical transnational perspective, one that examines not only policy transfers but also processes of decontextualization and recontextualization across different temporalities and spatialities (Nóvoa, 2017). Educational systems are shaped by layered temporalities, in which past reforms, institutional legacies, and unresolved conflicts continue to shape present possibilities (Tröhler & Lenz, 2015). The recent rhetoric of innovation and future-oriented projections attends to these historical assemblages and enables research to question narratives of inevitability—particularly those surrounding technology and AI—and to imagine alternative futures grounded in the common good and sustainable values.

NEXTGEN AI: ARTIFICIAL INTELLIGENCE IN THE SCHOOL OF THE FUTURE

The generative models of AI, arrived like a storm by the release of ChatGPT at the end of 2022. AI rapidly transforming economies, societies, and systems of knowledge, reshaping work, decision-making, and information flows and thus directly or indirectly impacts SDGs. Likewise, AI is rapidly reshaping education systems worldwide, transforming how knowledge is produced, accessed, and applied. It offers unprecedented opportunities to expand access, personalize learning, and improve systemic efficiency, yet also poses profound challenges related to equity, ethics, governance, and the very purpose of education (Schleicher & Mitchell, 2025).

PROMISE FOR FUTURE LEARNING: ACCESS AND PERSONALIZATION

In education, AI offers significant opportunities, including personalized learning, adaptive assessment, and expanded access (Jogezai et al., 2025). Adaptive learning systems can adjust content, pacing, and feedback to individual learners, helping to address heterogeneity in classrooms and long-standing inequalities in access to qualified teachers and quality education resources. Modern AI systems can answer most questions, write essays, and refine written work, among other things, thus became very popular among students in a short time. This triggered concerns of how to deal with these tools freely available to the students and how to take advantage of them to improve the education system.

A plethora of opportunities have been identified for the use of AI in education (Vincent-Lancrin & van der Vlies, 2020). For example, AI tools can support the personalization of teaching tailoring content to the individual needs of students. AI-based adaptive learning platforms can analyse student performance, identify gaps in learning, and suggest personalised materials and providing targeted exercises. The use of educational chatbots can assist students outside of school hours. Virtual study tutors using AI can help students to understand complex subjects by providing instant feedback and support and can also aid in writing, coding, art, etc. AI can support the inclusion of students with special needs by providing tools such as speech recognition software for students with dyslexia and virtual assistants to facilitate interaction in inclusive classrooms.

Teachers can look at AI as a resource for the assessment of routine tasks, grading essays and tests, and offering students quicker feedback. Language learning as well can be improved using personalized AI tutor to make conversation in another language and to improve pronunciation, adapting to the student's level. AI-based virtual science laboratories can involve students in planning and conducting investigations to gain knowledge and to develop skills in applying the scientific method.

However, realizing this potential requires moving beyond a narrow, instrumental view of technology (Bottino, 2020). From this perspective, AI can also enhance institutional management and public policy. Emerging technologies such as learning analytics and predictive models can support early identification of dropout risks, more efficient resource allocation, and continuous quality assurance particularly relevant to the growth of online and hybrid education—thus contributing to quality growth.

RISKS: INEQUALITY, ETHICAL CONCERNS, AND THE ILLUSION OF SUBSTITUTION

Despite its promise, there are also doubts surrounding the use of this technology: Will AI ameliorate or exacerbate inequity? What are the ethical implications of AI? Will AI replace teachers? AI systems act as “black boxes,” making it difficult to understand how decisions are made. It raises concerns related to data privacy, algorithmic bias, environmental costs, and the erosion of critical thinking (Pedro et al., 2019).

AI in education carries substantial risks such as potential amplification of existing inequalities. Education can serve as an equalizing force; however, when it involves technology, it may widen the gap between individuals or countries with unequal access to the technology and infrastructure (Bottino, 2016). Uneven adoption of AI across countries and regions may exacerbate the global digital divide, undermining the principle that sustainable development should be inclusive and leave no one behind. Without deliberate public policies and investment, AI may disproportionately benefit those with reliable connectivity, digital skills, and institutional capacity, thereby deepening digital and educational divides within and between countries.

Ethical challenges are equally important. The rapid incorporation of AI into society and education requires a thorough understanding of its ethical implications and the creation of strategies to maximise its benefits while minimising harm. Privacy concerns, algorithmic bias, transparency, and accountability are crucial in educational data related to children and adolescents to safeguard individual and collective rights.

Another major risk lies in the misconception that AI can replace educators or reduce education to automated instruction. Education is fundamentally a human endeavor involving judgment, ethical reasoning, dialogue, and social interaction. Over-automation risks weakening these dimensions and narrowing education to efficiency metrics, neglecting its formative role in humanity.

Moreover, biased or opaque algorithms risk reproducing social, cultural, and gender inequalities, undermining trust in educational systems. AI models learn from historical data, mostly from Western countries, which may contain biases (gender, racial, socioeconomic, etc.) or errors, thus in their application in the Global South, one has to be specially cautious about their outputs.

THE DUAL NATURE OF AI

One of the key risks identified in international studies is the emergence of polarized attitudes toward AI in education. When AI is framed either as a universal solution or as an inherent threat, policy debates become fragmented and evidence is often overshadowed by ideology. Such polarization can slow progress toward SDG 4 targets related to equal access to education and the provision of inclusive, safe, and effective learning environments.

AI systems have the potential to accelerate the access to information and amplify learning opportunities. However, the potential use of AI systems to generate convincing disinformation or to make mistakes if misled is of concern (Germani et al., 2024). Since AI attempts to replicate human language considering the probability of responses, based on internet searches, the form of the language may appear accurate, but there is no guarantee that the answer is correct.

Education can be an equalizer, but when it involves new technology there is a real potential of amplifying existing inequalities where people and countries lack the proper infrastructure (i.e. connectivity and computers) and human resource capacities. With difficult social and economic conditions, they may be unable to incorporate the technology into their education system.

Another potential risk of using AI systems is called bypass cognition, in which students may not learn certain basic concepts if AI tools are not properly implemented. There is a real risk that their use may decrease our cognitive abilities (e.g., [Jose et al., 2025](#); [Singh et al., 2025](#); [Kosmynan et al., 2025](#)). Technologies have been developed to make new things or make them faster, however, there is a risk to make us more dependent, less intelligent and lacking in critical thinking. AI has the potential to stimulate and enhance good practices but equally it has the power to reinforce inadequate ones; it can enable teachers to become creative designers of innovative learning experiences, but it can also reduce them to mere executors of pre-packaged lessons. The consequences of this dual nature of AI, capable of both enhancing and impoverishing the education landscape, are complex and multifaceted. Therefore, we must assure that AI is properly used to our benefit.

REDEFINING TEACHING AND RECONFIGURATION OF THE ARCHITECTURE OF LEARNING

As technology evolves, competencies for all levels of education have to be re-defined ([Ally & Mishra, 2024](#); [Ally, 2019](#)). The way learning is delivered and experienced has been revolutionized with the integration of digital technologies in educational settings ([Boztaş et al., 2025](#)). To maximize benefits of digital transformation in education, new models of education are needed for flexible access that place the learner at the center of the learning experience.

AI LITERACY, HUMAN COMPETENCIES, AND THE DEFINITION OF TEACHING

AI alters the conditions under which teaching and learning occur by shaping how content is accessed, produced and evaluated. It reshapes professional roles, pedagogical authority, and the balance between automation and human judgment within educational institutions.

Education systems currently operate “in-between time”: intelligent technologies are already widely available, yet institutional architectures, curricula, assessment models, and governance frameworks remain largely shaped by industrial-era assumptions. Transformative technologies do not deliver their full benefits unless organizations redesign their processes, roles, and cultures. Therefore, the uncritical adoption of AI for grading, content generation, or administrative efficiency—without revisiting curricula, assessment practices, and learning architectures—may result in marginal gains while amplifying ethical and pedagogical vulnerabilities. Conversely, when AI is embedded within redesigned educational ecosystems—competency-based curricula, adaptive learning pathways, authentic assessment, and strong ethical governance—it can support quality growth aligned with human development and social inclusion.

Education innovation in the AI era therefore encompasses not only the use of AI in education, but also education about AI to facilitate critical reflections and building of AI competences and AI literacy ([Stracke, 2024](#); [OECD, 2025](#)). From this perspective, AI literacy becomes a cornerstone of sustainable educational transformation and must be developed across education systems. It is not merely technical proficiency but a comprehensive set of competencies that includes understanding how AI systems function, their limitations, ethical implications, societal impacts, and appropriate human oversight. AI-literate learners and educators are better equipped to use these tools critically, responsibly, and creatively, rather than passively consuming algorithmic outputs ([UNESCO AI Competency Framework for teachers and students, 2024](#)).

AI literacy enables educators, students, and institutions to use intelligent systems effectively, and to question them, govern them, and decide when not to use them. Strengthening AI literacy and human-centered governance is therefore essential to ensure that AI contributes to equity, trust, and resilience in education systems worldwide.

While AI literacy is a cornerstone of sustainable educational transformation, translating this imperative into practice requires differentiated competency benchmarks that respect developmental stages, institutional contexts, and the distinct demands of operational versus critical engagement with intelligent systems. A meaningful operationalization distinguishes between two interdependent dimensions:

- Operational AI literacy: The technical capacity to use AI tools effectively—prompt engineering, data input/output management, basic understanding of model limitations, and appropriate tool selection for specific tasks.
- Critical/ethical AI literacy: The capacity to interrogate AI systems—recognizing algorithmic bias, questioning data provenance, understanding how training data shapes outputs, evaluating the trustworthiness of AI-generated content, and making informed decisions about when *not* to use AI.

Both dimensions are necessary but not sufficient on their own. Operational literacy without critical literacy produces competent but uncritical users. Critical literacy without operational literacy produces theoretical understanding without practical agency. The following framework (Table 1) proposes stage-appropriate benchmarks that scaffold learners from foundational awareness to autonomous, responsible AI engagement.

Table 1 AI Literacy Competency Benchmarks by Educational Stage.

DIMENSION	PRIMARY EDUCATION (AGES 6–12)	SECONDARY EDUCATION (AGES 13–18)	HIGHER EDUCATION & ADULT LEARNING
Operational Literacy: Using AI tools appropriately	• Recognize when an AI tool (e.g., voice assistant, recommendation system) is being used • Understand that AI is created by humans and can make mistakes • Basic prompt formulation (simple, concrete instructions) • Identify AI-generated vs. human-created content with guidance	• Effective prompt engineering (context, constraints, iterative refinement) • Use AI for brainstorming, drafting, summarization, and basic data analysis • Verify AI outputs against trusted sources • Understand model limitations (hallucination, outdated information) • Manage personal data when using AI tools	Advanced prompt strategies for domain-specific tasks • Integrate AI into research workflows (literature synthesis, coding assistance, data visualization) • Evaluate AI outputs for disciplinary accuracy and methodological soundness • Use AI for translation, accessibility, and collaborative tools • Understand API-based and local model deployment basics
Critical/Ethical Literacy: Governing and questioning AI	• Understand that AI can reflect human biases (gender, race, language) • Question whether an AI answer “makes sense” or seems unfair • Discuss simple ethical scenarios (e.g., “Should a robot decide your grade?”) • Know when to ask an adult for help interpreting AI outputs	• Identify algorithmic bias in real-world examples (hiring tools, grading systems, content moderation) • Analyze how training data shapes AI outputs • Understand privacy implications of sharing data with AI systems • Discuss environmental costs of large AI models • Evaluate when AI use is academically dishonest vs. appropriate assistance • Participate in school-level AI governance discussions	• Critically audit AI systems for bias, representation, and fairness • Understand legal and regulatory frameworks (GDPR, AI Act, algorithmic accountability) • Develop institutional AI use policies • Engage with ethical dilemmas (consent, surveillance, displacement of labor) • Advocate for transparent and accountable AI in public services (including education) • Design AI literacy curricula for others

The framework follows a spiral curriculum model. At primary level, the focus is on awareness, basic safe use, and cultivating a questioning disposition (“AI can be wrong or unfair”). At secondary level, learners develop operational fluency while simultaneously deepening critical analysis—moving from “how to use AI” to “why this AI output might be problematic” and “when to refuse AI assistance.” At higher education and adult learning, learners are expected to demonstrate both advanced operational competence and the capacity to govern, audit, and design responsible AI practices within professional and civic contexts.

Implementation pathways for achieving these benchmarks require curriculum integration across subjects—embedding AI literacy in language arts (evaluating AI-generated text), social studies (analyzing algorithmic bias in historical narratives), and science (understanding data training sets)—rather than isolating it to computer science. This must be supported by teacher professional development that models both operational and critical literacy, including

opportunities for educators to practice auditing AI tools used in their own contexts. Age-appropriate assessment strategies should emphasize performance tasks (e.g., “Compare an AI-generated answer to a verified source”) rather than multiple-choice tests of AI facts. Finally, institutional AI policies should be co-developed with students at secondary and higher levels, reinforcing that governance is a shared responsibility.

EDUCATION INNOVATION ADDRESSING LEARNING DIVERSITY AND TEACHER CHALLENGE

Schools tend to be conservative institutions because their core processes rely on long-term accumulation, which makes change inherently slow. Therefore, the adoption of AI in classrooms as a teaching and learning resource has been slow, sporadic, sceptical and subject to bans or substandard alternatives. From the very start of schooling there are significant variations in the capabilities of different children across cognitive, physical, behavioural, social and emotional domains. The challenge of meeting the disparate needs of the students within any class group could be daunting (Aranha, 2025; Langelaan et al., 2024; Schwab and Woltran, 2023).

For individual learning to progress, teachers must link the content to prior learning. However, the gap widens as the content becomes more complex and abstract owing to the many challenges in meeting the learning needs of all students in a class group. This results in many students feeling confused, disengaged and frustrated with schooling. Most find ways to cope while others drop out of school either literally or figuratively, making them “passengers” rather than engaged and enthusiastic learners.

To meet the needs of all learners in their classes, teachers must be highly skilled, well-resourced, and equipped with sufficient flexibility and agency to contextualize the curriculum and differentiate instruction. Emerging AI technologies now provide a concrete opportunity to address this longstanding challenge.

There is also the issue of the growing disruptions to schooling, which are becoming more common, more severe, and longer-lasting. Almost weekly there are media reports of education being disrupted due to extreme weather (Anadolu Agency, 2026), natural disasters (Hanung, 2026), political unrest (Hawkins, 2026), war (Mezha, 2026), and a variety of other unforeseen events. It has been argued that teachers must be prepared for an ever-changing classroom, and possess both the technical understanding and the pedagogical knowledge required to leverage digital tools—such as AI—regardless of geographic or temporal separation from their students (Barbour et al., 2023; Barbour & Hodges, 2024a; 2024b; 2024c; 2025; Hodges et al., 2022).

Contemporary AI systems and tools can be used as a teacher’s companion, in the classroom and beyond, to assist students in their learning development, enabling personalized experiences for their students and learning progress to occur. Whether it is designing individual lesson plans, assessing each student’s strengths and areas for further development, creating individualised tasks to support this, or generating reports on each student’s learning journey, AI-enhanced capabilities help sustain meaningful teacher-student relationships while facilitating engaged learning and ensuring progress. It is truly transformative.

In sum, AI offers teachers a significant opportunity to address a long standing issue in schooling, namely how to address students’ differences. By strengthening teachers’ knowledge for the critical use of AI, education systems can increase their capacity to tailor provision while safeguarding the shared foundations of the common schooling experience.

FROM TRANSMISSION TO FORMATION: TEACHERS AND EDUCATIONAL INSTITUTIONS IN THE AI ERA

AI has the potential both to support and to hinder progress toward SDGs, depending on how it is governed and embedded within education systems. The integration of AI into education systems requires a reconfiguration of the architecture of learning itself. The growing availability of content and automated support tools challenges traditional models centered on continuous expository instruction. Rather than signaling the end of educational institutions or teaching, this shift, would represent an opportunity to strengthen their core mission: formation rather than mere transmission.

As a matter of fact, artificial intelligence is accelerating a structural shift already underway in education: the transition from content transmission to human formation. As AI systems increasingly outperform humans in tasks related to information retrieval, pattern recognition, and procedural execution, the distinctive value of education lies more and more in cultivating competencies that remain irreducibly human such as ethical judgment, critical thinking, creativity, empathy, collaboration, and the capacity to act responsibly under uncertainty.

This transformation redefines the role of teachers and educational institutions. Educators in the AI era move from the center of exposition to the center of meaning-making. Teachers increasingly act as designers of learning experiences, mentors, and ethical curators; guiding students in the critical use of AI, ensuring transparency of authorship, and fostering reflective engagement with intelligent systems.

AI, in this sense, should be understood as a cognitive amplifier that augments human agency, not as a substitute for pedagogical judgment. In this context, AI reshapes the conditions of teaching and learning, redistributing cognitive tasks while elevating the importance of human judgment, mediation and ethical responsibility. AI can support the organization of learning pathways, identify knowledge gaps, and suggest adaptive strategies, but it cannot replace ethical judgment, mentorship, or the cultivation of critical thinking. Teachers remain essential mediators of meaning, values, and responsibility.

The following scenarios illustrate how teachers can deploy AI as a cognitive amplifier that cultivates ethical judgment, critical thinking, and meaning-making—directly supporting competencies essential for achieving the Sustainable Development Goals (SDGs).

Scenario 1: Simulating Resource Conflicts and Sustainable Peace (Secondary Social Studies)

SDG 16 (Peace, Justice and Strong Institutions) | SDG 13 (Climate Action)

Traditional transmission approach: Students use AI to summarize causes of a resource-based conflict (e.g., water scarcity, land disputes) and generate bullet points for memorization.

Formation-oriented approach: The teacher designs a structured activity where students prompt AI to simulate contrasting stakeholders—a displaced farmer, a government official, an environmental scientist, a community mediator. Students critically evaluate how the AI represents each perspective, identify whose voices are amplified or silenced, and compare AI-generated accounts with UN peacebuilding reports. The teacher then facilitates a debate: “What trade-offs between development and environmental protection does each stakeholder prioritize? How might AI bias shape our understanding of just solutions?” Students leave not with memorized facts but with refined capacity to navigate complex trade-offs essential for SDG 16 (peaceful, inclusive societies).

Scenario 2: Ethical Dilemma Analysis for Climate Justice (Upper Secondary/Higher Education Ethics)

SDG 13 (Climate Action) | SDG 10 (Reduced Inequalities)

Traditional transmission approach: Students ask AI to define ethical principles (e.g., intergenerational justice, polluter pays principle) and provide examples.

Formation-oriented approach: The teacher presents a real-world dilemma (e.g., climate adaptation funding allocation between vulnerable coastal communities versus emissions reduction; carbon offset programs affecting indigenous lands). Students first reason individually, then use AI as a “stakeholder simulator”—prompting the AI to defend opposing positions, surface hidden assumptions about responsibility and vulnerability, and identify trade-offs the student may have overlooked. The teacher guides reflection: “How does the AI’s training data reflect Global North versus Global South perspectives? What ethical reasoning about equity and historical responsibility must remain human?” The goal is strengthened capacity for structured ethical deliberation under uncertainty, directly supporting SDG 13 (urgent climate action) and SDG 10 (reduced inequalities).

Traditional transmission approach: Students ask AI to explain the circular economy concept and generate a report.

Formation-oriented approach: Students work in teams to address a local sustainability challenge (e.g., reducing school food waste, designing a product take-back system, evaluating supply chain sustainability). They use AI to generate and compare multiple solution pathways, critique AI-proposed interventions for feasibility, equity, and unintended consequences (e.g., labor displacement, regressive costs on low-income households), and refine their designs through iterative prompting. The teacher assesses not the final product alone but the quality of students' reasoning about AI's limitations—asking: "What local knowledge, cultural practices, or ethical considerations about decent work (SDG 8) did the AI miss? How would your solution affect different community groups?" This positions AI as a brainstorming partner while cultivating systems thinking and civic agency aligned with SDG 12 (responsible consumption and production).

Across these scenarios, several common principles distinguish formation-oriented from transmission-oriented AI use. In transmission mode, AI serves as an answer provider focused on information retrieval, with teachers acting as content deliverers and assessment targeting correct outputs for efficiency and coverage. In contrast, formation mode positions AI as an interlocutor, simulator, or brainstorming partner, emphasizing interrogation, comparison, and judgment. Here, teachers become activity designers and ethical guides, assessing students' reasoning processes and critical evaluation rather than mere answers. The ultimate goal shifts from efficiency and coverage to ethical discernment and meaning-making—competencies that lie at the heart of education for sustainable development.

Sustainability of investment in teacher development and institutional capacity allows AI tools to complement rather than replace human judgment and pedagogical expertise. International reports consistently underline the central role of teachers in fostering critical thinking, ethical reasoning, and social learning—capabilities essential to sustainable development but not readily automated. The integration of sustainability and ethics into AI-related curricula further supports learners' understanding of how AI shapes society, democracy, and the environment.

At the same time, many advances in AI-driven learning emerge from private-sector and research-oriented ecosystems, with public frameworks playing an enabling and coordinating role. Such developments are often accompanied by mechanisms of public reflection and oversight, including advisory councils or ethics boards that bring together educators, researchers, policymakers, students, and civil society to consider the social, ethical, and environmental implications of AI in education.

Higher education institutions play a strategic role in leading this transition. Universities are not only adopters of AI technologies but also key spaces for interdisciplinary research, ethical reflection, and evidence-based policy development. Their responsibility extends to fostering AI literacy, shaping governance frameworks, and preparing future professionals and citizens to engage critically with intelligent systems.

BRIDGING THE DIGITAL DIVIDE: LEARNING PATHWAYS FOR SUSTAINABLE FUTURE

The digital divide remains one of the most consequential barriers to achieving inclusive and equitable education in the AI era. While AI offers transformative potential for teaching and learning, from personalized instruction to accessibility enhancements, it would deepen existing inequalities, unless deliberate actions were taken to ensure universal access and capability. The G20's commitment to human-centered AI presents an opportunity to reform global education systems around three interconnected imperatives: equitable access to digital infrastructure, development of future-ready competencies, and integration of AI as a tool for sustainable development (Ally & Perris, 2022).

Developed countries still face significant challenges in ensuring equitable access to high-quality digital learning infrastructure (OECD, 2023). Although access to computers in schools is nearly universal in the most advanced systems, many institutions remain insufficiently equipped with a full range of effective digital tools. Moreover, substantial variation exists both between and within countries in the quality and functionality of digital equipment available in educational settings. Inequalities also persist in students' access to digital devices at home, as well as to educational software and online learning platforms. In addition, access to and adoption of more advanced technologies, such as cloud services, remain uneven.

Digital divides are substantially more pronounced in developing countries (Deloitte, 2025). Internet access and technology adoption remain limited in low- and lower-middle-income countries, where only approximately 27% and 53% of the population, respectively, have internet connectivity. Within these contexts, disparities in digitalisation persist between urban and rural areas, largely reflecting infrastructural constraints. Social inequalities further compound these challenges, as disadvantaged groups—particularly women and young people—are more likely to experience deficits in digital access and skills. In low-income countries, for example, around 90% of adolescent girls and young women (aged 15–24) remain offline, compared with 78% of their male counterparts.

The divide can be understood across four interconnected dimensions that operate hierarchically: the access divide (hardware, connectivity, and broadband infrastructure), the skills divide (digital literacy gaps), the usage divide (effective application of technology for learning), and the outcome divide (unequal tangible benefits from technology use) (van Deursen & Van Dijk, 2010; van Dijk, 2020). While access and skills have received considerable policy attention, the outcome divide is the most complex and consequential dimension, yet remains systematically underaddressed.

The outcome divide refers to the phenomenon whereby individuals with comparable access and similar skill levels nonetheless derive substantially different tangible benefits—such as academic achievement, employment outcomes, or civic participation—from their technology use. This divergence occurs because socio-economic and cultural factors shape how and toward what ends technology is used. Research consistently shows that students from higher socio-economic backgrounds are more likely to use digital tools for “capital-enhancing” activities: creative production, problem-solving, research, and self-directed learning. In contrast, students from disadvantaged backgrounds, even when provided with equal access and basic skills training, disproportionately use technology for consumption-oriented activities: entertainment, passive social media scrolling, and low-level information retrieval (Scheerder et al., 2017; Ireland & Lestari, 2025).

This divergence in usage patterns is not a matter of individual choice alone. It reflects deeper structural asymmetries: differential parental guidance and digital modeling, varying exposure to enrichment activities outside school, differences in peer networks and academic aspirations, and the unequal distribution of institutional support that translates basic digital access into meaningful learning outcomes. Schools serving affluent communities tend to integrate technology into inquiry-based, collaborative, and higher-order learning tasks, while schools serving disadvantaged communities often deploy technology for drill-and-practice, test preparation, and behavioral monitoring—a pattern that reproduces rather than disrupts existing achievement gaps (Warschauer, 2011; Reich, 2020).

When technology interventions focus exclusively on access and skills—distributing devices and offering basic training—they create the illusion of equity while leaving the most consequential dimension untouched. Students may sit in classrooms with one-to-one computing, possess functional digital skills, yet remain trapped in usage patterns that do not translate into academic gain, critical thinking development, or future economic mobility. The aggregate consequence is that educational technology investments risk functioning as regressive transfers: disproportionately benefiting those with the cultural and social capital to convert access into advantage, while doing little to close—and potentially widening—the outcome gap between privileged and marginalized learners.

Addressing the outcome divide therefore requires moving beyond distributional metrics toward qualitative interventions that shape usage patterns: curriculum reform that embeds technology in higher-order learning tasks, teacher professional development that emphasizes pedagogical integration over tool operation, family and community engagement that supports capital-enhancing uses at home, and assessment systems that reward creative and critical applications of technology rather than mere procedural fluency. Without such measures, the promise that AI and digital technologies will serve as equalizing forces in education will remain unfulfilled, and the digital divide will persist as a mechanism for reproducing, rather than reducing, social and economic inequality.

DESIGNING INCLUSIVE LEARNING PATHWAYS

Bridging the digital divide requires tiered, adaptive learning pathways that recognize diverse starting points while building toward sustainable participation in the digital economy. Foundational digital literacy forms the baseline, beginning in primary education and extending through adult learning programs. It encompasses basic digital communication, computational thinking, data literacy, and critical engagement with AI and digital ethics. With more than 739 million youth and adults still lacking basic literacy skills globally, and approximately 250 million children failing to acquire basic literacy skills (UNESCO, 2025), this foundational layer must be contextually appropriate and culturally relevant.

Advanced and vocational pathways address emerging sectoral demands through targeted technical training programs. Open Educational Resources (OER) have demonstrated cost-effectiveness at scale, with research showing academic outcomes comparable to traditional textbooks and 85–90% of students citing cost as a key reason for adoption (UNESCO, 2020). A global network of OER repositories now provides cost-free access to quality materials, though effective use still depends on connectivity, devices, and educator support. Practical solutions such as local servers and low-bandwidth platforms like India's DIKSHA model help mitigate infrastructure limitations.

Continuous upskilling through lifelong learning acknowledges that skills for sustainable participation are dynamic rather than fixed. AI-powered platforms can support adaptive reskilling throughout adult life, particularly as labor markets undergo technological transformation. A synthesis of 30 peer-reviewed studies (2010–2024) suggests AI-powered personalized learning systems in higher education yield roughly 30% positive effects on engagement and performance, yet pedagogical barriers exceed technical ones (Vorobyeva et al., 2025). This highlights the need for comprehensive teacher professional development that addresses pedagogy, technical competence, and ethics.

POLICY FRAMEWORK: FIVE STRATEGIC PILLARS

A five-pillar policy framework can guide governments seeking to close the digital divide in the AI era. First pillar: Expand affordable, reliable infrastructure. Universal broadband, especially in rural and underserved regions, remains foundational. Interim solutions such as community Wi-Fi, local servers, and low-bandwidth platforms can accelerate access while long-term fiber investments proceed. For many low-income learners who rely solely on cellular data plans, these arrangements determine whether AI-enabled learning is possible at all (State Educational Technology Directors Association, 2025).

Second pillar: Invest in educator capacity. Technology without teacher expertise perpetuates digital inequality, as many educators struggle to integrate AI-based tools meaningfully into their practice (Tan, 2024). Recent surveys show that roughly three-quarters of teachers report feeling underprepared for AI, with major barriers including lack of knowledge and time (Fitzpatrick, 2025; Imagine Learning, 2024). Structured, ongoing professional development, rather than isolated workshops, is essential for equipping teachers to use AI ethically and effectively (European Schoolnet, 2023; Yang, 2025). Professional learning should address the Technological Pedagogical Content Knowledge (TPACK) framework, which emphasizes the interplay among content, pedagogy, and technology (Mishra & Koehler, 2006).

Third pillar: Reform curricula for digital-sustainability integration. Digital literacy, AI awareness, and sustainability competencies should be embedded across the curriculum from early childhood through higher education. Saudi Vision 2030 initiatives integrate robotics, coding,

and AI literacy from early grades. This illustrates how curriculum reform can align with broader economic and social goals (Global Business Outlook, 2025; National Curriculum Center, 2025).

Fourth pillar: Leverage OER and AI responsibly. The UNESCO (2019) recommendation on OER establishes a global framework for openly licensed educational materials. When combined with responsible AI governance (bias audits, fairness-aware algorithms, and transparency) OER can democratize access to high-quality content. However, persistent risks of algorithmic bias and unequal representation demand careful design, monitoring, and diverse participation in content creation (UNESCO, 2024).

Fifth pillar: Structure effective public-private partnerships with governance guardrails for sustainable development. Collaboration between governments and educational technology firms can accelerate inclusive digital transformation when grounded in equity-oriented regulation and accountability (Praxis Center for Policy Studies, 2021). However, private corporations’ growing influence over education raises concerns about market-driven fragmentation, algorithmic bias, and erosion of education as a public good (Edwards et al., 2024). Without deliberate governance, PPPs risk undermining SDG 4, 10, 16, and 17—serving commercial interests rather than equitable, sustainable development.

Table 2 Governance Checklist for SDG-Aligned Public-Private Partnerships in AI Education.

STAGE	GOVERNANCE QUESTION	SDG ALIGNMENT	MINIMUM SAFEGUARD
Procurement & Design	Does the partnership explicitly prioritize underserved communities (rural schools, low-income districts, learners with disabilities, girls and women) in its stated objectives and success metrics?	SDG 4 (Equity), SDG 5 (Gender Equality), SDG 10 (Reduced Inequalities)	Mandatory equity impact assessment before contract approval; public disclosure of targeted beneficiary numbers and baseline indicators disaggregated by gender, income, location, and disability status.
Data Governance & Privacy	Who owns student and teacher data? Is data used only for agreed educational purposes, and is it protected from commercial re-use, surveillance, or secondary monetization?	SDG 16 (Privacy Rights, Institutional Accountability)	Data sovereignty clause prohibiting data sales, third-party sharing, or use for non-educational AI training without explicit, informed, opt-in consent from families and educators.
Algorithmic Accountability & Bias	Have the AI systems been audited for bias across race, gender, language, socioeconomic status, and disability? Do audits specifically examine impacts on marginalized groups?	SDG 4 (Inclusive Quality Education), SDG 5 (Gender Equality), SDG 10 (Reduced Inequalities)	Independent, publicly disclosed bias audits conducted pre-deployment and annually thereafter; mechanism for educators, families, and students to challenge or appeal algorithmic decisions affecting learning opportunities.
Environmental Sustainability	Have the environmental costs of AI systems (energy consumption, hardware lifecycles, e-waste) been assessed and minimized?	SDG 12 (Responsible Consumption), SDG 13 (Climate Action)	Mandatory environmental impact assessment; commitment to energy-efficient models, renewable-powered data centers, and responsible e-waste management; public disclosure of carbon footprint.
Pedagogical Transparency & Human Agency	Are teachers and students informed when AI is making recommendations, grading, or tracking behavior? Can they override or opt out of automated decisions?	SDG 4 (Learner-Centered Pedagogy), SDG 8 (Decent Work and Teacher Professional Autonomy)	Mandatory disclosure of AI use in all learning platforms; human-in-the-loop requirement for high-stakes decisions (grading, placement, progression, resource allocation).
Open Standards & Interoperability	Does the partnership include open standards to prevent vendor lock-in and allow schools to switch providers without data loss, ensuring long-term affordability and choice?	SDG 4 (Sustainable Education Systems), SDG 9 (Innovation & Infrastructure)	Open API requirements; data portability rights; contract terms limited to 3–5 years with competitive re-bidding to prevent monopoly capture.
Teacher Capacity for Sustainable AI Use	Does the partnership include funded, ongoing professional development for teachers—not just technical training but also critical AI literacy, ethical reasoning, and pedagogical integration for sustainability competencies?	SDG 4 (Teacher Quality), SDG 8 (Decent Work), SDG 12 (Responsible Consumption)	Minimum 15% of contract value allocated to teacher professional development, co-designed with educators and sustainability experts, not solely by vendor.
Multi-Stakeholder Oversight	Are there independent, multi-stakeholder oversight mechanisms (including educators, parents, civil society, students, and sustainability experts) with authority to audit, pause, or terminate non-compliant partnerships?	SDG 16 (Inclusive Decision-Making, Accountability), SDG 17 (Partnership Accountability)	Statutory oversight committee with binding enforcement powers and balanced representation (government, civil society, educators, families, students); public annual report on equity outcomes, bias audit results, and environmental impact.
Just Transition & Exit Strategy	What happens to data, algorithms, and access when the partnership ends? Are there provisions for transitioning to alternative providers or public infrastructure that protect educational continuity for underserved communities?	SDG 4 (Resilient Education Systems), SDG 10 (Preventing Digital Colonization)	Mandatory data escrow and source code deposit for critical algorithms; publicly documented transition plan approved before contract signing; guarantee that no community loses access to essential educational AI due to contract termination.

The checklist above (Table 2), as a condition for public procurement, would signal that education PPPs are judged by their measurable contribution to SDGs—rather by cost savings alone. Without these guardrails, PPPs risk deepening the very inequalities they purport to address.

The five strategic pillars outlined above are not merely theoretical constructs; they directly operationalize commitments made under recent G20 presidencies. The New Delhi Leaders’ Declaration (G20, 2023) explicitly called for “bridging the digital divide” and “promoting digital public infrastructure” as enablers of inclusive growth. Under India’s presidency, G20 Education Working Group priorities emphasized foundational learning, leveraging technology for equitable access, and strengthening teacher capacity.

Building on this trajectory, South Africa’s 2025 G20 presidency has framed AI as a public good for inclusive development, with a specific focus on: (i) digital skills for all, (ii) responsible AI governance in public services (including education), and (iii) reducing structural inequalities through technology. Table 3 maps the five pillars derived in this paper to these explicit G20 commitments, demonstrating how education innovation serves as a concrete steering mechanism for sustainable development in the AI era.

Table 3 Mapping Five Strategic Pillars to G20 Policy Priorities (2023–2025).

STRATEGIC PILLAR	OPERATIONAL FOCUS	DIRECT ALIGNMENT WITH G20 COMMITMENTS	EXAMPLE OF G20-ENDORSED MECHANISM
Pillar 1: Expand affordable, reliable infrastructure	Universal broadband (rural/underserved); community Wi-Fi; low-bandwidth platforms	New Delhi Declaration: “Quality infrastructure and digital public infrastructure for all” (para 27); South Africa 2025 priority on closing connectivity gaps	G20 Digital Infrastructure Financing Facility
Pillar 2: Invest in educator capacity	TPACK-based professional development; AI literacy for teachers	New Delhi Declaration: “Investing in teacher training and professional development” (para 20); South Africa 2025: “Human-centered AI capacity building”	G20 Teacher Policy Framework; UNESCO-G20 AI Competency pilot programs
Pillar 3: Reform curricula for digital-sustainability integration	Embedding AI literacy, digital ethics, and SDG competencies across all levels	New Delhi Declaration: “Promoting future-ready curricula” (para 22); G20 2024 commitment to “green and digital skills”	G20 Skills Strategies; Saudi Vision 2030 (as G20 member exemplar)
Pillar 4: Leverage OER and responsible AI	Open Educational Resources; bias audits; fairness-aware algorithms; transparency	New Delhi Declaration: “Promoting open, equitable, and secure knowledge ecosystems” (para 48); South Africa 2025: “AI as a public good”	UNESCO OER Recommendation (endorsed by G20); G20 AI Principles (2019/updated 2024)
Pillar 5: Structure effective public-private partnerships	Equity-oriented regulation; accountability mechanisms; prioritizing underserved communities	New Delhi Declaration: “Responsible public-private collaboration for digital transformation” (para 35); South Africa 2025: “Inclusive innovation partnerships”	G20 TechSprint; Global Partnership for Education (GPE) – G20 joint financing

Each of the five strategic pillars finds direct expression in recent G20 declarations and working group outcomes. This alignment transforms education innovation from a parallel agenda into a core delivery mechanism for G20 commitments on digital equity, responsible AI, and sustainable growth. International cooperation should therefore move beyond general endorsements toward joint infrastructure investment, mutual recognition of AI literacy standards, and peer-reviewed accountability for closing the digital divide.

EPISTEMIC JUSTICE AND DATA SOVEREIGNTY: RE-CENTERING THE GLOBAL SOUTH IN AI-DRIVEN EDUCATION

Notably AI models predominantly trained on Western datasets risk reproducing cultural, linguistic, and epistemic biases when deployed in Global South contexts. However, this is not merely a technical problem of algorithmic fine-tuning; it is a question of epistemic justice—who gets to define legitimate knowledge, whose languages and worldviews are encoded into educational infrastructure, and whose voices are systematically marginalized in the AI-driven transformation of learning.

Epistemic justice, conceptualized and extended to digital contexts, requires that education systems do not simply import AI tools designed elsewhere but actively participate in shaping the knowledge systems embedded within those tools (Fricker, 2007). When a student in Nigeria,

Indonesia, or Brazil uses an AI-powered learning platform trained predominantly on English-language, Western-curated corpora, they encounter not neutral assistance but a particular epistemic orientation—one that may devalue local knowledge, erase indigenous concepts, and frame sustainable development through external rather than community-defined priorities.

Data sovereignty offers a complementary framework for addressing this challenge. Data sovereignty asserts that communities, regions, and nations have the right to govern the collection, use, and storage of data generated within their borders—including the training data that shapes AI models used in education (Kukutai & Taylor, 2016; Walter & Suina, 2019). Applied to education, this principle implies that Global South countries should not merely be consumers of AI systems designed in and for the Global North, but active producers of locally grounded, culturally responsive AI resources. This includes the right to: (i) determine which knowledge and cultural practices are represented in educational AI, (ii) establish governance frameworks for student and community data, (iii) develop AI literacy curricula that reflect local ethical traditions, and (iv) participate in the design of AI evaluation standards that prioritize equity over efficiency.

The role of international research collaboration is therefore not to transfer solutions from North to South, but to enable capacity for contextually appropriate solution generation from within. The G20, with its membership spanning both Global North and South, is uniquely positioned to advance this agenda through the following mechanisms:

First, collaborative infrastructure for locally trained AI models. International partnerships can support the development of open-source, low-resource AI models trained on regionally curated datasets that represent local languages, oral traditions, indigenous knowledge systems, and culturally specific pedagogies. Initiatives such as Masakhane (African natural language processing) and the Global South AI for Climate and Health networks demonstrate that focused, collaborative investment can yield models that outperform generic Western alternatives for local educational tasks (Nekoto et al., 2020).

Second, community-governed OER repositories with AI augmentation. Rather than imposing externally designed OER, international collaboration should fund and facilitate the creation of locally governed digital repositories where educators and communities contribute, validate, and adapt educational materials. AI can then be deployed to enhance discoverability, translation, and personalization—but within governance structures that ensure epistemic diversity and community consent. The UNESCO OER Recommendation (2019) provides a framework, but G20 leadership could establish funding mechanisms specifically for sovereign OER infrastructure in low- and middle-income countries.

Third, reciprocal AI literacy and research capacity building. Epistemic justice requires that researchers from the Global South are not merely informants or data sources but co-designers of AI education research agendas. G20-sponsored fellowship programs, joint doctoral training networks, and open-access publication platforms can redress the current imbalance in AI education research output—where less than five percent of indexed publications on AI in education originate from African or Latin American institutions despite comprising a significant share of global learners.

Fourth, ethical frameworks grounded in plural values. Current AI ethics guidelines are predominantly shaped by Western philosophical traditions (utilitarianism, rights-based frameworks). International research collaboration should explicitly fund comparative ethical inquiry that surfaces and operationalizes concepts from diverse traditions—such as ubuntu (collective personhood in Southern African thought), buen vivir (harmonious living from Andean cosmologies), and vasudhaiva kutumbakam (world as one family from South Asian traditions). These frameworks offer alternative foundations for AI governance that prioritize relationality, ecological embeddedness, and intergenerational responsibility over individual optimization.

For G20 policymakers, operationalizing epistemic justice and data sovereignty requires concrete commitments: (i) dedicating a portion of digital infrastructure funding to locally trained AI models and sovereign data storage, (ii) requiring participatory design processes in AI education procurement, (iii) establishing metrics for epistemic diversity in AI training datasets, and (iv) creating G20-recognized standards for community consent and benefit-sharing in educational

AI. Without such measures, AI-driven education innovation risks becoming a new vector of epistemic colonization—efficiently delivering content that systematically marginalizes the knowledge, languages, and values of the communities it purports to serve.

CONCLUSION: EDUCATION INNOVATION AS A STEERING MECHANISM FOR SUSTAINABLE DEVELOPMENT IN THE AI ERA

The attainment of SDGs warrants a forward-looking agenda for the G20, positioning education as a strategic lever for inclusive, human-centered, and sustainable development in the AI era. Rather than offering a definitive agenda, this article proposes a set of conceptual orientations that can serve as a compass in an increasingly fragmented landscape. By returning to the core questions of education—educating, teaching, and schooling—while critically engaging with AI and global governance, it elucidates the role of education innovation in the AI era as a constructive force in the pursuit of sustainable and socially just futures.

Education research shapes how societies understand themselves, how they imagine collective futures, and how they respond to inequality and uncertainty. In the AI era, the question of what to research in education is no longer merely academic; it is fundamentally political, ethical, and societal. For the G20, fostering meaningful collaboration in education research requires more than innovation rhetoric. It demands a renewed reengagement with the purposes of education, an awareness of temporal and spatial complexities, and a commitment to sustaining education as a public, democratic, and ethical endeavour.

The educational impact of AI cannot be reduced to deterministic narratives of promise or threat. Its transformative effects on education will depend not only on the technology itself, but also on the quality of human choices—pedagogical, institutional, and political—that shape how it is adopted. The central challenge is to ensure that AI-driven transformation promotes quality growth, defined not only by efficiency and scale, but also by equity, ethical responsibility, human development, and sustainability. Redefining teaching roles, redesigning learning architectures, and strengthening AI literacy are interdependent conditions for ensuring that AI contributes to inclusive and sustainable development. The future of education in the AI era is thus not primarily a technological question, but a human and institutional one.

“Design for learning” principles stand at the core of AI-empowered education systems. Building AI literacy (the capacity to critically understand, govern, and responsibly use AI systems) emerges as a core condition for meaningful transformation. As AI makes knowledge acquisition readily accessible, the essential value of education lies more in relationships, passion, intuition, ethical judgement and empathy, cultivating critical thinking, global perspectives, and social responsibility. AI literacy supports democratic resilience, informed citizenship, and professional autonomy, enabling educators and learners to decide not only how to use AI, but also when and why not to use it. Ultimately, “it is up to us” to build an AI-driven future we can be proud of, one that prioritizes humanity, fairness, and progress.

Bridging the digital divide remains a central condition for realizing these ambitions. Equitable access to infrastructure, sustained investment in educator capacity, curriculum reform integrating digital and sustainability competencies, responsible use of AI and open educational resources, and effective public–private partnerships are structural requirements for justice and sustainability in the AI era.

As education systems navigate this transitional period, the need for coordinated leadership, ethical governance, and international cooperation becomes increasingly evident. The challenges and risks associated with AI in education highlight the need for strong governance frameworks grounded in human rights, democratic values, and enforceable safeguards for inclusion and accountability. National AI strategies must increasingly emphasize the alignment of technological innovation with social inclusion, labor protection, information integrity, and environmental sustainability.

With paradigm shift in knowledge production and dissemination, success depends increasingly not only on how effectively knowledge is produced and disseminated, but also how knowledge is connected and translated into global impact. Quality must evolve with scale. Rapid expansion

in research output must be matched by investments in research culture, evaluation standards, and global engagement. Countries that strengthen the research capacity of a broad range of institutions and take international openness as a strategic asset are better positioned to sustain long-term competitiveness. Mobility, collaboration, and co-authorship are central mechanisms of knowledge dissemination and influence (Bottino et al., 2009).

International and cross-country research on AI in education, supported by G20 collaboration, contributes to a stronger evidence base and helps reduce policy fragmentation—avoiding both technological determinism and undue resistance to innovation.

The G20's framing of AI as a public good for inclusive development, reaffirmed during South Africa's 2025 presidency, creates an opportunity for coordinated global action. International cooperation should combine infrastructure investment, educator capacity building, and support for contextually appropriate solutions rather than one-size-fits-all models. Reducing learning loss and avoiding GDP losses, while unlocking human potential, requires urgent, coordinated implementation of evidence-based strategies.

To conclude, in the AI era, education innovation serves as a steering mechanism for sustainable development. By shaping skills, values, and governance frameworks, education influences whether AI contributes to inclusive growth, environmental responsibility, and social cohesion, or whether it reinforces existing risks and inequalities. Leveraging AI to expand access and improve quality, while grounding its use in evidence, ethics, and international cooperation, enables education to guide technological change toward a more sustainable, just, and resilient future.

DATA ACCESSIBILITY STATEMENT

Data sharing is not applicable to this article as no datasets were generated or analysed during the current study.

SUSTAINABLE DEVELOPMENT GOALS (SDGs)

This study is linked to the following SDG(s): No poverty (SDG 1), Zero hunger (SDG 2), Good health and well-being (SDG 3), Quality education (SDG 4), Gender equality (SDG 5), Clean water and sanitation (SDG 6), Affordable and clean energy (SDG 7), Decent work and economic growth (SDG 8), Industry, innovation and infrastructure (SDG 9), Reduced inequalities (SDG 10), Sustainable cities and communities (SDG 11), Responsible consumption and production (SDG 12), Climate action (SDG 13), Life below water (SDG 14), Life on land (SDG 15), Peace, justice, and strong institutions (SDG 16), and Partnerships for the goals (SDG 17)[Specify name of the related SDGs.

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