Enhancing quality education through AI and youth-driven digital platforms - A scalable model for achieving SDG 4

MUNGAI Kibiku Samuel[1]

Abstract

This paper examines how Artificial Intelligence and youth-driven digital platforms can transform education to achieve Sustainable Development Goal 4. Using a conceptual synthesis of policy frameworks, a literature review on AI in education, and access statistics, it critiques the limitations of traditional models and proposes a scalable, learner-centred framework that leverages mobile technology, Artificial Intelligence-enabled personalisation, and creator-educators. The model addresses barriers such as digital divide, data privacy, and teacher displacement while emphasising ethical governance, public-private partnerships, and inclusive access. By reframing education as flexible, culturally contextualised, and human-centred, the paper outlines a pragmatic pathway to equitable, high-quality learning for digital-native generations, especially in underserved regions, and positions Artificial Intelligence as a complement to, not a replacement for, teachers.

Keywords: quality education; artificial intelligence in education; mobile-first learning; digital platforms; creator-educators; digital divide; policy and governance.

JEL Classification: I20, I28, O33

Introduction

In 2015, the United Nations adopted the 2030 Agenda for Sustainable Development, consisting of 17 Sustainable Development Goals (SDGs) aimed at addressing the most pressing global challenges. Among them is SDG 4: Quality Education, which seeks to ensure inclusive and equitable quality education and promote lifelong learning opportunities for all (United Nations). This goal recognises education as a fundamental human right and a critical enabler of sustainable development, poverty reduction, and social mobility.

Despite global efforts, the world remains significantly off track in achieving SDG 4. According to the United Nations Educational, Scientific and Cultural Organisation (UNESCO) Global Education Monitoring Report (GEM) (2023), more than 244 million children and youth are still out of school, and many who are in school are not acquiring basic literacy and numeracy skills. The COVID-19 pandemic further exacerbated these inequalities, revealing deep gaps in educational access, digital infrastructure, and the adaptability of learning systems in both high- and low-income countries (United Nations, 2023).

Traditional educational systems, designed during the industrial era, have struggled to keep pace with the demands of the 21st century. They often rely on standardised, "one-size-fits-all" instruction that does not reflect the diversity of student needs, learning styles, or technological realities. As the global community seeks to accelerate progress toward SDG 4, there is a growing recognition that innovation, flexibility, and learner-centred approaches must become central to education reform.

This paper argues that integrating Artificial Intelligence (AI) and youth-centric digital platforms, such as YouTube and mobile-first learning environments, can play a transformative role in achieving SDG 4. By leveraging AI's personalisation capabilities and the accessibility

---

[1] Budapest University of Economics and Business

of digital content delivery, education can become more inclusive, engaging, and scalable, especially for digitally native generations.

The current state of education

Modern educational systems are often criticised for their stagnation and failure to evolve in tandem with societal and technological advancements. Traditional classrooms, characterised by rigid structures and standardised testing, have remained largely unchanged for over a century, despite significant technological progress in other sectors (Prince Ea, 2016). This outdated model of education is ill-suited to meet the diverse needs of today's learners and the demands of a future workforce dominated by AI and other advanced technologies.

Albert Einstein famously remarked, "Everybody's a genius, but if you judge a fish by its ability to climb a tree, it will live its whole life believing that it is stupid" (Prince Ea, 2016). This analogy underscores the inadequacy of "one-size-fits-all" educational approaches that fail to recognise and nurture individual talents and learning styles.

These systems were effective for their time, serving the needs of factory-based economies and hierarchical labour markets. However, in the context of today's fast-evolving digital world, such models are increasingly obsolete and misaligned with the skills, interests, and needs of contemporary learners.

The conventional classroom model emphasises standardised curricula, teacher-centred instruction, and high-stakes assessments. While these components aim to ensure consistency and control, they often suppress creativity, overlook individual learning differences, and contribute to student disengagement. Many learners are labelled as underachievers not because they lack potential, but because the system fails to acknowledge their unique learning styles and cultural contexts.

"One-size-fits-all" education has also struggled to keep pace with rapid technological change. Despite the widespread availability of smartphones, internet access, and online resources, many schools still rely on outdated textbooks, rigid timetables, and passive lecture formats. Moreover, the dominance of summative exams and grade-based competition prioritises memorisation over critical thinking, collaboration, and innovation, which are essential for thriving in the 21st-century global economy.

This disconnect is particularly pronounced among Generation Z and Alpha learners, who have grown up in digitally connected environments and increasingly demand interactive, personalised, and relevant learning experiences. These learners are not disengaged from education itself, but rather from a system that does not reflect how they live, communicate, or think. The rigid and homogenised nature of traditional education often stifles creativity and critical thinking, skills that are crucial in the modern world.

Purpose and significance of the study

The purpose of this study is to explore how integrating sustainable artificial intelligence (AI) with youth-centric digital platforms can enhance the quality, equity, and adaptability of learning systems to meet the goals of SDG 4: Quality Education. Specifically, this research investigates how AI technologies, when deployed ethically and inclusively, can support personalised learning, improve educational access, and foster engagement among digitally native learners. It examines the role of informal digital platforms such as YouTube, which already serve as alternative learning spaces for millions of young people around the world.

The significance of this study lies in its emphasis on merging technological innovation with sustainable educational practices. Although considerable attention has been given to the transformative potential of AI in high-income contexts, its strategic use in low-resource environments remains underexplored (Arruda & Arruda, 2024). Similarly, youth-driven

learning behaviours on digital platforms are often overlooked in mainstream educational policy and planning, despite their growing influence and scale (Sterling, 2024).

By addressing these gaps, this study contributes to the broader discourse on how education systems can evolve to meet contemporary needs. It also highlights the importance of designing AI-driven learning ecosystems that are not only technologically advanced but also aligned with human values, inclusion, and sustainability (D, 2024; Abunamous et al., 2022). In doing so, the paper offers practical insights and a conceptual framework that can guide educators, policymakers, and technology developers in building more resilient, equitable, and learner-centred education systems.

Rethinking quality education in the 21st century

Limitations of traditional classroom models

The conventional model of education, rooted in industrial-era design, is increasingly seen as inadequate for preparing learners for the demands of the 21st century. Traditional classrooms often rely on standardised teaching methods, rigid curricula, and teacher-centred instruction, which offer limited flexibility for adapting to students' individual learning needs and styles (Abunamous et al., 2022; Saputra et al., 2023). These systems prioritise uniformity and compliance, often at the expense of creativity, critical thinking, and learner autonomy.

One of the most critical limitations lies in the "one-size-fits-all" approach. Students are frequently grouped by age rather than ability or interest, and instruction is delivered at a fixed pace with minimal differentiation. This creates a learning environment in which advanced students may become disengaged due to a lack of challenge, while struggling students fall further behind due to insufficient support (Arruda & Arruda, 2024).

Moreover, traditional education models typically depend on rote memorisation and high-stakes testing as indicators of academic success. These methods often fail to assess the learner's capacity for problem-solving, collaboration, or adaptability, which are essential in a fast-evolving, digitally connected world (Sahney et al., 2004). The system rewards compliance and accuracy over curiosity and innovation, producing graduates who may excel at test-taking but lack the competencies needed to thrive in real-world, complex situations.

The physical structure of classrooms also reinforces outdated pedagogical assumptions. Students are arranged in rows, expected to remain passive while teachers deliver information from the front, mirroring factory-floor layouts of the past century (Prince Ea, 2016). This configuration discourages interaction, experimentation, and dynamic engagement, thereby limiting students' ability to take ownership of their learning process.

Crucially, these systemic limitations persist even as technological infrastructure is expanding faster than educational reform. For example, by the end of 2023, nearly 70% of the global population was a smartphone user, with over 7 billion smartphone subscriptions worldwide, projected to rise to 8 billion by 2028 (Laricchia, 2024). This rapid technological adoption, particularly in low- and middle-income regions, offers a unique opportunity to deliver digital education at scale, yet traditional systems are not designed to leverage it.

Innovations such as Starlink, which now delivers internet access to remote and rural communities globally, make it possible to imagine a world where quality education can reach the most underserved learners. If governments and global institutions, such as the UN, were to invest in online tutors, subsidise access to digital platforms, and make subscriptions to tools like Starlink affordable, they could overcome geographic barriers and close critical equity gaps in education delivery.

Therefore, the limitations of traditional classroom models are not merely pedagogical; they are structural, digital, and policy-related. To achieve SDG 4, education systems must

evolve beyond static classrooms and harness the global growth of mobile technology and digital access to build flexible, inclusive, and future-ready learning environments.

Rise of digital native learners

Today's learners are not just students in classrooms; they are digital natives. Born into a world saturated with technology, members of Generation Z and Generation Alpha have grown up with smartphones, tablets, and instant internet access. Their behaviours, expectations, and ways of processing information differ significantly from those for whom traditional educational systems were designed.

Digital-native learners are accustomed to interactivity, autonomy, and personalisation in their content consumption. Platforms like YouTube, TikTok, and Khan Academy have become major sources of informal education, where students can learn on demand, rewind or replay difficult concepts, and choose instructors who resonate with their learning style and interests. This shift reflects a broader movement toward learner-centred education, where engagement and relatability matter as much as curriculum standards.

Data support this behavioural shift. As mentioned above, in 2023, nearly 70% of the global population used smartphones, with over 7 billion active subscriptions (Laricchia, 2024). These numbers are projected to increase, indicating that mobile-first learning is becoming the new default. Students today can access content from anywhere on buses, at home, or in rural communities, provided they have a connection. With innovations like Starlink providing internet in remote areas, access to online education is no longer a privilege but a scalable opportunity.

What sets digital-native learners apart is not just their access to technology, but how they expect it to be used. They are increasingly self-directed in their learning, seeking platforms that offer flexibility, visual content, gamification, and interaction. Moreover, they gravitate toward educators who feel authentic, relatable, and human, often creators rather than traditional institutional educators. As a result, digital platforms are becoming not only entertainment hubs but learning ecosystems, organically integrated into students' daily lives.

This evolving learner profile calls for a rethinking of educational delivery models. Rather than competing with digital platforms, education systems must integrate them, leveraging their reach, familiarity, and adaptability to make learning more engaging and effective. Recognising and adapting to the habits and preferences of digital-native learners is a crucial step in making quality education both inclusive and relevant, in line with the targets of SDG 4 (UNESCO, 2023).

The role of artificial intelligence in education

Artificial intelligence (AI) is rapidly transforming industries worldwide, and education is no exception. In the context of Sustainable Development Goal 4 (SDG 4), AI offers powerful tools for advancing inclusive, equitable, and quality education for all. By supporting personalisation, enhancing engagement, and automating administrative burdens, AI has the potential to address many of the systemic challenges faced by traditional education systems, particularly those in underserved regions.

Personalisation and adaptive learning

One of the most promising applications of AI in education is personalised learning. AI systems can analyse student performance in real time and adapt content, pace, and feedback to suit each learner's strengths, weaknesses, and preferences. This approach stands in stark contrast to the "one-size-fits-all" instruction, allowing students to progress at their own speed and revisit difficult concepts as needed (Arruda & Arruda, 2024; Saputra et al., 2023).

Platforms such as Khanmigo, powered by Generative Pre-trained Transformer (GPT) based AI, offer real-time, tailored tutoring experiences across subjects. Similarly, applications like Dream Box and Squirrel AI in China use machine learning algorithms to adjust lesson difficulty based on user interactions, helping close performance gaps while keeping learners motivated. These tools are especially beneficial for students with learning disabilities or those in multilingual and multicultural contexts.

AI-powered assessment and feedback

AI also enhances formative assessment and feedback loops, allowing teachers and learners to monitor progress more accurately and in a timely manner. Intelligent systems can instantly evaluate quizzes, assignments, or written content, reducing the burden on educators while giving students targeted insights on how to improve.

Such systems also help track learning patterns and dropout risks, enabling proactive interventions. For example, AI-integrated learning management systems in universities can predict which students are likely to disengage and suggest timely support strategies (D, 2024). This is particularly useful in large-scale, online or hybrid education environments.

Language, accessibility, and inclusion

AI technologies are also helping to bridge language and accessibility gaps, making education more inclusive. Tools like speech recognition, real-time translation, and text-to-speech applications empower students with disabilities or those learning in non-native languages (Arruda & Arruda, 2024). For learners in multilingual countries or displaced communities, such tools offer a lifeline to education that is both culturally and linguistically responsive.

Mainly in areas with acute teacher shortages, AI can serve as a support mechanism, supplementing classroom instruction or facilitating independent study when in-person teachers are unavailable.

Limitations and responsible use

Despite its promise, the use of AI in education is not without risks. Concerns include data privacy, algorithmic bias, and over-reliance on automation. If not carefully designed and deployed, AI systems may reinforce existing inequalities or reduce the human elements essential to effective teaching and mentorship (Abunamous et al., 2022; Sterling, 2024).

Open platforms introduce risks, variable content quality, distraction from recommendation feeds, and opaque ranking algorithms. Mitigations include curated playlists aligned to national syllabi, age-appropriate modes, offline packs for controlled use, and transparent recommendation criteria.

To be truly effective, AI must be implemented ethically and transparently, with ongoing oversight and teacher involvement. As technology advances, it should not replace educators, but rather empower them to focus on deeper, human-centred interactions with students.

Youth-driven learning culture and digital platforms

YouTube as a learning ecosystem

In the digital age, platforms traditionally associated with entertainment are rapidly transforming into alternative learning environments. Among these, YouTube has emerged as a dominant player in informal education, particularly among digital native youth. As the world's second most visited website and largest video-sharing platform, YouTube hosts a vast array of educational content ranging from kindergarten through 12th grade (K-12) lessons and

university lectures to language tutorials, science explainers, and do-it-yourself skill development. As shown in Figure 1, top educational creators reach audiences at a scale unmatched by formal institutions (Social Blade, 2025).

For today's learners, YouTube is not merely a tool for passive viewing; it is a dynamic, interactive ecosystem where they can learn at their own pace, choose educators they relate to, and explore content that aligns with their passions and interests. This aligns with Generation Z's preference for autonomy, relatability, and flexibility in learning (Sterling, 2024). Educational creators like Khan Academy, CrashCourse, and Kurzgesagt have amassed millions of followers and billions of views, underscoring a massive and growing demand for self-directed, creator-led learning.

For example, as of 2025, Cocomelon has amassed over 192 million subscribers and an astonishing 199.8 billion views, while ChuChu TV follows with 95.8 million subscribers and 54.7 billion views. Baby Shark Pinkfong reaches an audience of 81.2 million subscribers with over 49 billion views. Other prominent channels, including Infobells Hindi and Billion Surprise Toys, add significantly to this total, bringing the collective reach to over 360 billion views across just a handful of top educational platforms.

#	Grade	Name	Subscribers	Views	Videos
1st	A+	Cocomelon - Nursery Rhymes	193M	201.98B	1.54K
2nd	B+	ChuChu TV Nursery Rhymes & Kids Songs	96.2M	54.93B	865
3rd	A	Baby Shark - Pinkfong Kids' Songs & Stories	81.6M	49.74B	3.54K
4th	A	Infobells - Hindi	69.6M	42.45B	777
5th	B+	Billion Surprise Toys	57.6M	12.75B	1.41K

Top 100 Education YouTube Creators by Subscribers   104ms

Figure 3: *Top educational YouTube creators by subscribers and views (2025)*
Source: *Social Blade, accessed 2025*

This level of engagement far surpasses the reach of most traditional education systems and signals a paradigm shift in how learning is consumed and delivered. YouTube's multilingual content, visual storytelling, and comment-based interaction make it particularly inclusive for learners with varying literacy levels or language backgrounds. Its mobile accessibility also allows learners in low-resource areas to engage with high-quality educational content, often at little or no cost, especially when paired with expanding internet coverage from services like Starlink.

YouTube's distinctiveness as a learning tool lies in its ability to blend education with entertainment, a concept known as edutainment. This increases retention and motivation, especially among younger audiences. Additionally, learners can subscribe to channels, receive updates, and build long-term learning relationships with creators who serve as informal mentors. While YouTube cannot replace formal education entirely, it provides a powerful supplement that aligns with the habits, values, and lifestyles of modern learners. Recognising its potential as a learning ecosystem and investing in the development of high-quality, culturally relevant content is essential for making education more accessible, engaging, and inclusive in the digital era.

Learner autonomy, creator-educators, and mobile-first behaviour

As education shifts into the digital age, young people are no longer passive recipients of knowledge; they are becoming active curators of their own learning journeys. This transformation is driven by a blend of technological access, behavioural changes, and the proliferation of user-generated content. Learner autonomy, supported by creator educators and mobile-first technology, is shaping a new paradigm of education, one that aligns closely with the goals of SDG 4 in both spirit and scale.

Learner autonomy

Digital-native learners increasingly prefer to learn on demand, at their own pace, and through formats that align with their personal preferences. This autonomy enables them to revisit difficult concepts, skip ahead when confident, and explore topics driven by curiosity and real-world relevance. Such self-directed learning fosters intrinsic motivation, critical thinking, and lifelong learning habits, all of which are pillars of quality education (Arruda & Arruda, 2024; Sterling, 2024).

Learner autonomy is critical in bridging equity gaps. Students in underserved or rural areas, for instance, may not have access to qualified teachers or consistent school attendance. Still, with digital resources and agency, they can pursue learning independently, guided by technology and informal mentors.

The rise of creator educators

Unlike traditional educators limited by geography and institutional constraints, creator-educators use platforms like YouTube, TikTok, and Instagram to reach global audiences. These educators are often peer-aged or culturally relatable, which increases their impact and trust among youth. Their content is typically modular, visual, and emotionally engaging, allowing learners to connect with material beyond textbooks and lectures.

Mobile-first behaviour

By the end of 2023, nearly 70% of the global population used a smartphone, with over 7 billion active subscriptions projected to reach 8 billion by 2028 (Laricchia, 2024). These statistics represent more than technological growth; they mark a shift in learning behaviour.

Smartphones have become the primary learning device for millions of students, particularly in Africa and the Global South, where access to computers and tablets remains limited. With mobile-optimised educational content, learners can study while commuting, in low-resource school settings, or from rural homes connected through satellite internet services such as Starlink.

Mobile-first learning is not only about convenience but also about scalability, equity, and resilience. It enables education to reach learners who would otherwise be excluded due to geography, conflict, or poverty. By embracing learner autonomy, supporting creator educators, and designing for mobile-first use, education systems can become more aligned with how young people naturally learn.

Synergising AI and youth-centric platforms: a new model for SDG 4

Proposed framework for inclusive, scalable, and personalised learning

While AI and digital platforms each hold transformative potential on their own, it is in their synergy that the greatest opportunity for reimagining education lies. The proposed model for achieving SDG 4 combines the personalisation and intelligence of AI with the accessibility,

flexibility, and relatability of youth-centric digital platforms, such as YouTube, mobile apps, and creator-led content ecosystems.

The proposed architecture is summarised in Figure 2. This hybrid model addresses the three key pillars of quality education as defined by UNESCO: accessibility, equity, and learning outcomes by using technology not to replace teachers or schools, but to augment and scale personalised learning in ways previously impossible.

How the model works: core components

1. Learner-centred AI engine

AI technologies serve as the personalisation core of the system. They deliver adaptive content tailored to each student's performance, pace, and preferences, provide real-time tutoring and individualised feedback, analyse behavioural data and progress trends to identify at-risk learners and recommend interventions to help prevent dropout or disengagement (Arruda & Arruda, 2024; D, 2024).

2. Digital content platforms

Platforms like YouTube, Khan Academy, and TikTok Edu act as distribution hubs for educational content. They host short, multilingual, and engaging videos from trusted creator-educators. Enable two-way interaction through comments, likes, and content sharing. Foster learning communities by enabling learners to subscribe to, follow, and engage with content that aligns with their identity and interests (Sterling, 2024).

3. Mobile-first access

Mobile phones are the most accessible learning tools worldwide. This model prioritises delivery via smartphones, optimised for low bandwidth. It supports use in rural or underserved areas, leveraging technologies like Starlink to expand internet access. It also empowers displaced or low-income learners with flexible, on-demand access to education (Laricchia, 2024).

4. Human–machine collaboration

Rather than replacing educators, the model positions technology as an assistant, allowing teachers to take on roles as facilitators, mentors, and learning designers. AI handles curriculum adaptation, formative assessment, and learner analytics. Digital creators complement formal instruction by offering culturally relevant, accessible, and engaging content (Saputra et al., 2023).

5. Sustainability and equity layer

For the model to be inclusive and ethical, it must be supported by strong governance and equitable investment. This layer includes policy frameworks that ensure responsible AI use, data privacy, and algorithmic transparency.
Global partnerships provide funding for content creation, infrastructure, and affordable connectivity. Platform standards promote diversity, representation, and accessibility in educational content (Abunamous et al., 2022).
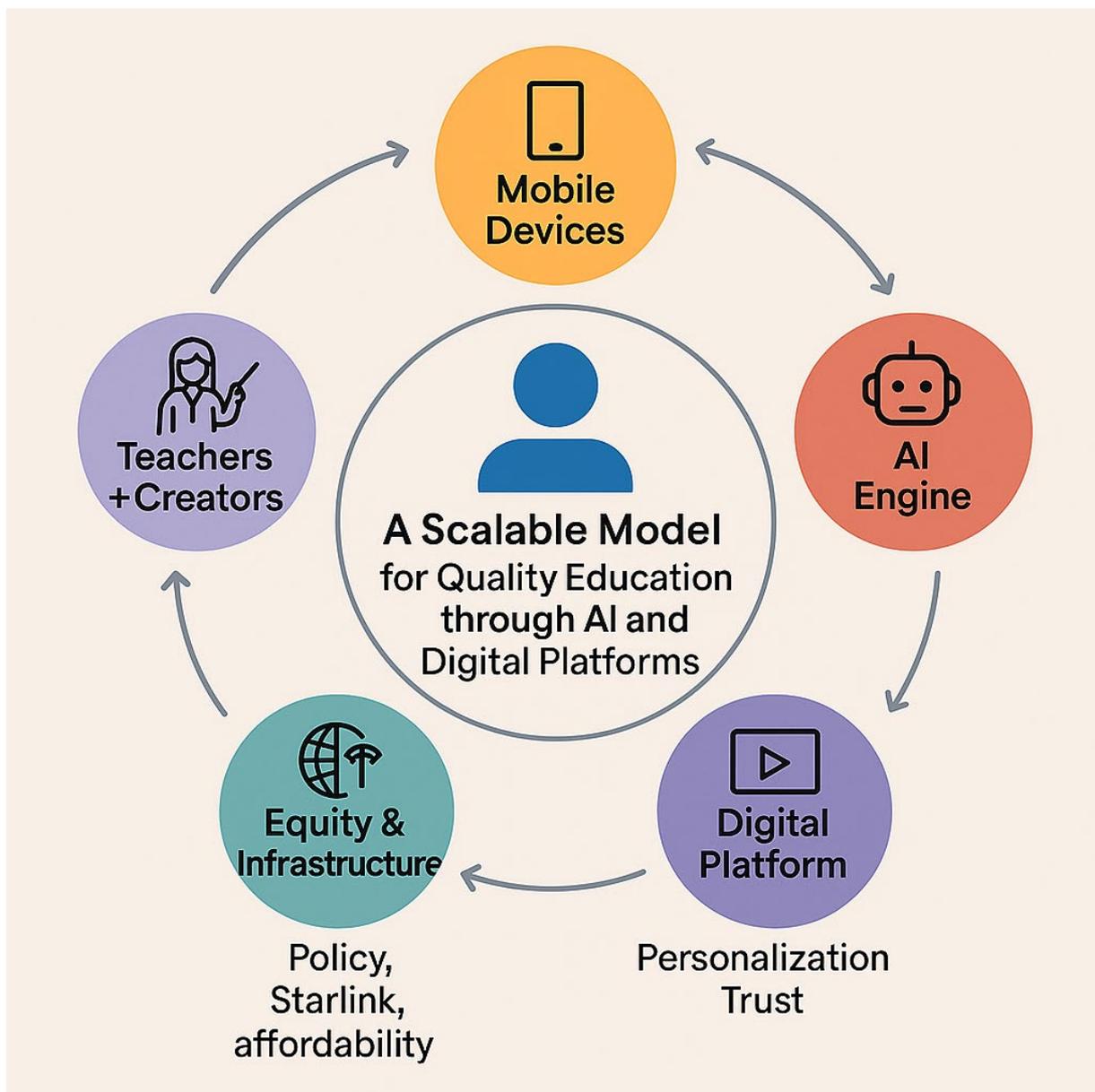
Figure 4: *A scalable model for quality education through AI and digital platforms*
Source: *Author's design, informed by UNESCO (Education 2030; GEM Reports)*

Real-world potential: Such a model could be especially impactful in regions where teacher shortages are severe, learning loss due to COVID-19 persists, and traditional schooling is inaccessible due to conflict, poverty or migration.

By leveraging AI to scale personalisation and platforms such as YouTube to scale access and engagement, this model presents a viable path to universal, inclusive, and quality education, a central aim of SDG 4 (Arruda & Arruda, 2024; D, 2024; GEM Report, 2023).

How AI + platform-based learning = scalable quality education

Achieving SDG 4, "Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all", requires more than simply building schools or distributing textbooks. It demands scalable, flexible, and context-sensitive solutions that meet learners where they are geographically, digitally, and emotionally. The combination of artificial intelligence and youth-centric digital platforms presents a unique opportunity to fulfil this

demand by tackling the three main dimensions of education reform: access, personalisation, and engagement.

1. Scalability through mobile and platform infrastructure

With over 70% of the world's population using smartphones and platforms like YouTube, TikTok, and Khan Academy already reaching hundreds of millions of learners, digital education has the infrastructure in place and deployed, especially in the Global South (Laricchia, 2024). Unlike brick-and-mortar schools, digital platforms do not require massive physical investments to scale. A single high-quality video lesson can reach millions instantly, in multiple languages and formats.

When integrated with AI tutors, learners can also receive tailored support from concept explanations to practice quizzes and real-time feedback. Services such as Starlink expand the digital frontier further, making education accessible even in remote, conflict-affected, or impoverished areas.

2. Personalisation at scale

Traditional classrooms struggle to accommodate individual needs. AI solves this by adjusting content to each learner's pace, learning gaps, and preferred formats. Whether through voice interfaces, predictive analytics, or personalised recommendations, AI adapts to learners dynamically, something no single teacher can do for hundreds of students.

When combined with digital platforms, this personalisation becomes instantly scalable. A student watching a science video on YouTube, for example, can be guided by an AI overlay suggesting follow-up videos, practice exercises, or even a conversation with a chatbot tutor. This ecosystem reduces dropout risk, boosts retention, and builds learner confidence (Arruda & Arruda, 2024; Saputra et al., 2023).

3. Engagement through culture and choice

One of the core problems with traditional schooling is the lack of emotional connection to content. In contrast, platform-based learning allows learners to choose instructors they relate to, content formats they enjoy, and topics they care about. This sense of control and cultural resonance increases motivation and deepens understanding. Learners on digital platforms can interact through comments, share content, subscribe to educators they admire, and form peer-learning networks that mimic the social dimension of learning in a digital space.

Personalisation, flexibility, and reach

The integration of artificial intelligence and youth-driven digital platforms brings together three transformative features that traditional education models often lack: personalisation, flexibility, and global reach. These features are not merely innovations; they are essential for making education inclusive, adaptable, and equitable, especially in the context of Sustainable Development Goal 4 (SDG 4).

Personalisation

AI technologies can tailor educational content based on each learner's performance history, learning speed, individual strengths and weaknesses, and preferred learning styles.
This level of personalisation is impossible to achieve in most traditional classrooms, where teachers must address diverse learners with a single method. Through real-time feedback, adaptive learning paths, and individualised recommendations, AI makes the learning experience more relevant and effective for each student (Arruda & Arruda, 2024; D, 2024).

In a world where millions of students are left behind by standardised instruction, personalised learning not only improves academic outcomes, it also fosters self-confidence, agency, and engagement, particularly for marginalised groups and students with special needs.

Flexibility

Digital platforms and mobile technologies provide learning anytime, anywhere. Whether a student is in a refugee camp, a rural village or commuting in an urban area, access to a smartphone and internet connection enables participation in learning activities.

This flexibility is vital for students with limited access to formal schooling, learners balancing education with work or caregiving responsibilities, and those recovering from disruptions such as pandemics or conflict. Mobile-based, on-demand learning allows individuals to pause, rewind, and revisit lessons, engage with bite-sized modules, or explore topics based on personal interests and at their own pace, ultimately creating a learner-driven experience that adapts to real-life constraints and fosters continuous engagement (Laricchia, 2024).

Reach

While traditional education systems are bound by geography, infrastructure, and personnel, digital platforms and AI transcend these boundaries. YouTube channels, AI tutors, and education apps can deliver content to millions instantly and on a scale. Combined with emerging internet access solutions like Starlink, even the most remote areas can now be integrated into the global learning network.

The reach of digital education is further amplified by features such as multilingual content, visual and auditory formats, culturally relevant creators, and community-based interactions and feedback loops. These elements enhance inclusivity by accommodating diverse linguistic, cultural, and cognitive needs, thereby enabling more learners, regardless of background, to access, engage with, and benefit from educational content. All together these elements push the global community closer to achieving truly universal, equitable, and high-quality education in line with the objectives of SDG 4.

Together, personalisation, flexibility, and reach create an agile, inclusive, and resilient learning ecosystem. By embedding these qualities into educational systems through AI and digital platforms, we not only address the gaps in current systems but also build a foundation for an education model that can evolve with generations to come.

Barriers and ethical considerations

Digital divide and infrastructure issues

Figure 3 shows persistent access gaps from the global distribution of internet users. While the integration of artificial intelligence and digital platforms holds immense potential to transform education, its implementation is not without challenges. Chief among these is the persistent digital divide, which continues to limit equitable access to technology-enhanced learning. Without addressing these foundational inequalities, the risk remains that AI-driven education may exacerbate rather than reduce disparities, especially in low-income, rural, and marginalised communities.
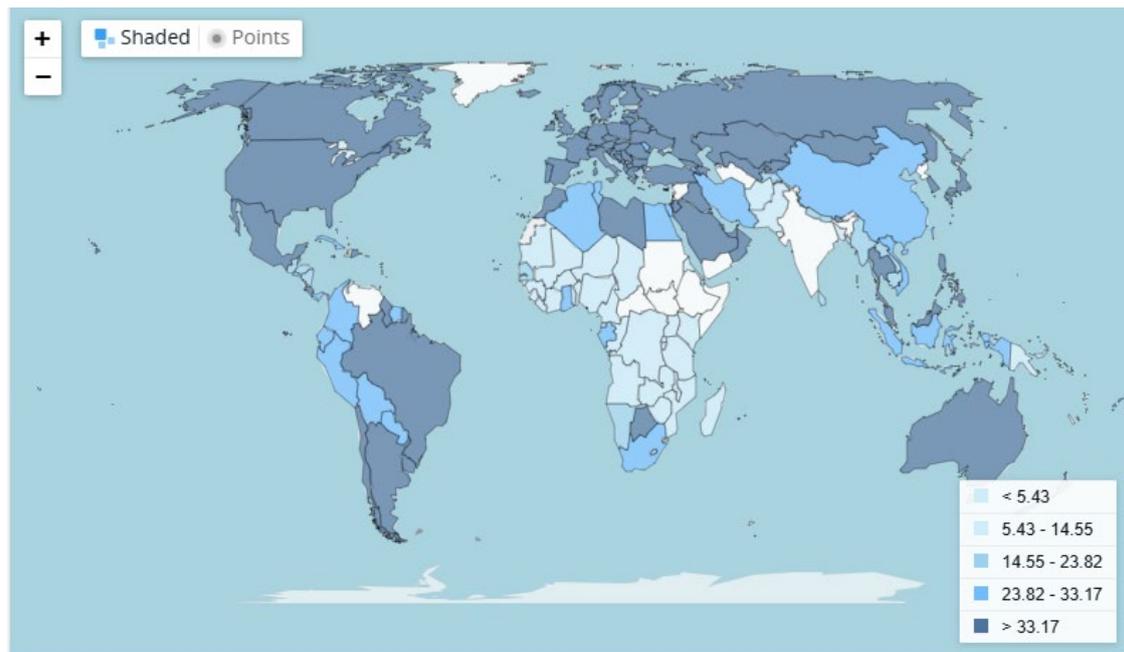
Figure 5: *Global digital divide*
Source: *World Bank, World Telecommunication/ICT Indicators Database, International Telecommunication Union (ITU) (2023)*

The digital divide manifests in several interrelated dimensions

1. Connectivity gaps

In many parts of the Global South, reliable internet access is still a major barrier to digital education. According to UNESCO (2023), nearly half of the world's population lacks stable internet access, leaving millions of people unable to access online platforms. Even in areas with some connectivity, data costs remain prohibitive for students who rely on mobile devices as their primary learning tool. Although services like Starlink are beginning to provide satellite-based internet in remote locations, widespread affordability and government support are needed to scale such infrastructure.

2. Device and hardware limitations

Access to devices is another constraint. While global smartphone ownership has reached nearly 70% of the population, device quality varies widely (Laricchia, 2024). Many learners rely on outdated phones with limited storage, poor screen resolution, or low processing power, making it difficult to engage with interactive or video-heavy educational content. Households with multiple children, device sharing and limited availability can reduce learning time and continuity, especially when synchronous learning or long-form lessons are required.

3. Electricity and technical support

Infrastructural issues such as intermittent electricity, especially in rural or conflict-affected areas, further restrict access to consistent learning opportunities. Even when the internet and devices are available, students may face frequent disruptions due to power outages or a lack of charging facilities. The lack of local technical support, such as device repair services or digital literacy training, can leave learners disconnected for extended periods, even with minor technical issues.

4. Educational infrastructure and policy readiness

In many education systems, policy frameworks have not kept pace with technological advancement. Schools may lack the capacity to integrate AI tools, and teachers may not be trained to use digital platforms or manage hybrid learning environments. This limits the

effectiveness of even the best technologies when introduced without systemic support (Saputra et al., 2023; Sterling, 2024).

Data privacy and algorithmic bias

As artificial intelligence becomes more embedded in educational technologies, new ethical and regulatory challenges have emerged, chief among them being data privacy and algorithmic bias. These concerns are not merely technical; they strike at the core of equitable, inclusive, and trustworthy education. If left unaddressed, they risk undermining the very goals that AI-driven solutions seek to achieve under SDG 4.

1. Data privacy concerns in learning environments

AI systems require large amounts of data to function effectively, tracking user behaviour, collecting performance metrics, and adapting content in real time. While this data-driven personalisation enhances learning, it also introduces significant risks related to student privacy.

Learners, particularly minors, often lack the legal understanding or digital literacy to give informed consent regarding how their data is collected, stored, and used. Moreover, educational platforms may engage third-party vendors for cloud storage, analytics, or ad services, raising questions about who owns the data, who can access it, and for what purposes (Arruda & Arruda, 2024).

Without robust data protection policies, students' personal and academic information may be exposed to misuse, profiling, or commercial exploitation, especially in countries lacking strong digital rights frameworks. This is particularly concerning in contexts where government surveillance or data-based discrimination could have lifelong consequences.

2. Algorithmic bias and inequity in AI systems

AI systems are not inherently neutral; they reflect the biases embedded in their training data, design processes, and deployment contexts. In education, this can lead to algorithmic discrimination, where certain groups of learners receive less favourable content recommendations, are misclassified in assessments, or are filtered out of learning pathways based on inaccurate assumptions.

For example, AI trained primarily on data from English-speaking or high-income contexts may underperform for students in multilingual, indigenous, or underrepresented communities. Predictive algorithms might reinforce stereotypes by systematically disadvantaging learners from low-performing schools or marginalised ethnic groups, thereby widening educational inequality rather than reducing it (Abunamous et al., 2022).

The opacity of many commercial AI systems makes it difficult for educators or policymakers to understand how decisions are made, or to contest potentially harmful outputs. This lack of transparency not only weakens trust in AI tools but also raises ethical questions about accountability in learning outcomes.

Teachers as facilitators, not replaced by tech

As artificial intelligence and digital platforms continue to reshape educational landscapes, a key concern among educators, unions, and policymakers is the fear of displacement. However, effective integration of AI and youth-centric technologies is not about replacing teachers, but about redefining and elevating their role in a modern learning ecosystem.

Teachers play irreplaceable human roles in education that machines cannot replicate. They provide emotional support and mentorship, foster social skill development, mediate sensitive or complex content, and adapt instruction to students' cultural, psychological, and personal contexts. While AI may outperform humans in content delivery, data processing, or automated grading, it lacks the empathy, ethical judgement, and relational intelligence required

to guide learners through challenges, insecurities, and social development stages (Sterling, 2024; Abunamous et al., 2022).

Policy and implementation recommendations

Government support for AI in education

Governments play a central role in shaping the future of education, and their support is essential for the ethical, equitable, and impactful implementation of artificial intelligence (AI) in learning environments. To ensure AI serves as a force for educational inclusion rather than exclusion, policy frameworks must proactively guide innovation while addressing risks and inequalities.

1. National strategies and regulatory frameworks

Many countries still lack formal strategies for integrating AI into their education systems. To foster sustainable implementation, governments must establish comprehensive national policies that define the scope and goals of AI in education, standards for data protection and ethical use, curriculum alignment and teacher training requirements, valuation metrics and equity safeguards.

These strategies should be developed in consultation with educators, learners, AI developers, and civil society, ensuring that technological solutions are both pedagogically sound and socially responsible (Arruda & Arruda, 2024).

2. Investment in infrastructure and access

Effective AI integration requires a robust digital infrastructure. Governments must invest in internet connectivity, particularly in rural and underserved regions, and subsidise access to mobile data, devices, and platforms. Initiatives like public-private partnerships with providers such as Starlink could dramatically expand access in remote areas, transforming the internet from a luxury item into a learning necessity (Laricchia, 2024).

Governments should support open-source AI tools that promote educational equity, grants or funding schemes for educational content creators, and the development of local language and culturally contextualised content.

3. AI literacy and teacher capacity building

Without adequate support, even the most advanced AI systems risk becoming underused or misused. Government policy must prioritise professional development for teachers, equipping them with the skills to interpret and utilise AI-generated learning data, blend AI tools with classroom instruction and identify and report algorithmic bias or malfunction.

Ministries of education should integrate digital and AI literacy into pre-service teacher education and offer ongoing upskilling opportunities.

4. Monitoring and evaluation mechanisms

Government support must also encompass robust monitoring and evaluation mechanisms to assess the true impact of AI tools on academic performance, equity, learner engagement, and overall well-being. Policies should mandate periodic reviews focused on critical indicators, including data privacy compliance, disparities in learning outcomes across demographic groups, and user satisfaction among both teachers and students. These evaluations are essential for ensuring that AI implementation remains aligned with the principles of inclusive, equitable, and quality education as outlined in SDG 4 (UNESCO, 2023).

United Nations support for AI-driven quality education

The United Nations and its specialised agencies, particularly UNESCO, United Nations International Children's Emergency Fund (UNICEF), and the International Telecommunication Union (ITU), have a pivotal role in guiding, funding, and scaling global efforts to harness AI and digital innovation for achieving SDG 4. Their involvement is especially vital for ensuring

that such innovations reach low- and middle-income countries, conflict-affected regions, and marginalised populations often left behind by national initiatives.

1. Normative guidance and global standards

UNESCO has taken a leading role in establishing ethical guidelines for the use of AI in education, providing global frameworks through publications such as the Global Education Monitoring (GEM) Reports and the Recommendation on the Ethics of Artificial Intelligence. These guidelines ensure that AI is human-centred, inclusive, and non-discriminatory; that data-privacy and child-protection standards are upheld; that cultural and linguistic diversity is respected in educational content; and that AI tools are used to enhance, not replace human interaction in learning. These standards are essential for informing policies and procurement processes, particularly in countries lacking national AI strategies.

2. Funding and infrastructure support

The United Nations can play a pivotal role in accelerating progress toward SDG 4 by supporting both infrastructure development and equitable access to AI-powered educational tools. Key actions include subsidising digital learning platforms in low-income countries, partnering with connectivity providers such as Starlink to expand internet access in remote and underserved regions, and providing grants to content creators, particularly from the Global South to develop inclusive, culturally relevant educational materials. By strategically directing resources toward digital equity, the UN can help ensure that no learner is excluded from AI-enhanced education due to poverty, geography or displacement.

3. Global collaborations and knowledge exchange

Through initiatives such as Education 2030 and the Broadband Commission, the UN fosters global partnerships among governments, tech companies, research institutions, NGOs and civil society. These multi-stakeholder collaborations support scalable pilot programmes, promote the sharing of best practices, and encourage open research on AI's educational impact. The UN can create a centralised repository of vetted AI tools, teacher training modules, and impact data, especially valuable for small nations or conflict-affected regions seeking guidance.

4. Advocating for learners' rights in the digital age

UN has a unique mandate to advocate for the rights of children and youth in digital spaces. As AI and platform-based learning expand, new challenges around digital consent, AI profiling, and algorithmic exclusion require rights-based global governance. UNICEF's work on child rights in the digital world can be expanded to ensure that education-related AI tools prioritise equity, safety, and well-being.

Public and private partnerships with EdTech creators

As the educational landscape becomes increasingly shaped by digital innovation, public-private partnerships (PPPs) between governments, NGOs, and education technology (EdTech) creators have emerged as a critical mechanism for expanding access to quality learning. These collaborations are essential for bridging the gap between policy aspirations and technological implementation, especially in regions with limited public sector capacity.

1. Leveraging Innovation and Reach

EdTech creators ranging from global platforms like Khan Academy and YouTube Learning to regional start-ups and grassroots content creators bring creativity, agility, and deep user engagement. Their understanding of learner behaviour, mobile-first design, and platform algorithms enables them to produce engaging, scalable content that aligns with how young people actually learn (Sterling, 2024).

Through strategic partnerships, governments and international bodies can leverage the strengths of EdTech creators and digital platforms to enhance educational delivery. These collaborations can help localise content into multiple languages and cultural contexts, adapt learning materials to align with national curricula, and ensure access to creator educators in

regions where formal teaching resources are limited. Additionally, such partnerships enable the integration of AI-based personalisation tools into content delivery systems, ensuring that learning experiences are both inclusive and tailored to individual learner needs.

2. Funding and incentivising inclusive content development

Public funding and incentive schemes can be strategically directed toward content creators who prioritise equity and inclusion, particularly those developing educational materials for girls and young women in STEM, indigenous and minority language learners, learners with disabilities, and displaced or refugee communities. These creators play a vital role in bridging content and accessibility gaps often overlooked by mainstream education systems. Support can take the form of microgrants, visibility partnerships or platform infrastructure assistance, ensuring that creators have both the resources and motivation to align their work with the inclusive aims of SDG 4.

3. Infrastructure and platform access

Governments can also collaborate with private companies to expand access to digital learning platforms and devices, especially for underserved populations. Key strategies include offering zero-rated data packages for educational content, as successfully implemented in countries like South Africa and India, partnering with telecom providers to lower subscription fees for students, and co-investing in the distribution of devices such as Chromebooks or tablets preloaded with curriculum-aligned materials. In return, private companies benefit from enhanced market access, strengthened brand credibility, and the opportunity to generate positive social impact. This creates a mutual value proposition that supports long-term, sustainable collaboration in the education sector.

4. Oversight, ethics, and alignment with public goals

To ensure that public-private partnerships in education serve the public interest, it is essential to establish transparent governance structures. Governments should take the lead in setting ethical and equity standards for educational content, ensuring interoperability and robust data privacy protections, and monitoring the impact of these collaborations on learning outcomes and inclusion. Additionally, care must be taken to avoid overreliance on a single provider or platform, which could undermine diversity and resilience in the education ecosystem. Ideally, such partnerships should be shaped by independent evaluations and meaningful civil society input, ensuring they remain learner-centred, transparent, and aligned with national education goals.

Affordable access to mobile-based learning

Access to mobile devices and connectivity is no longer a luxury; it is a gateway to education for millions worldwide. As mobile-based learning becomes the primary medium for young people, especially in developing regions, ensuring affordability is essential to bridge the digital divide and deliver on the promise of inclusive, equitable, and quality education.

1. Smartphones as primary learning devices

Globally, smartphones are the most widely used digital tools for learning, with nearly 70% of the world's population owning one and over 7 billion subscriptions in 2023, a figure expected to reach 8 billion by 2028 (Laricchia, 2024). For many learners in rural or low-income communities, smartphones are the only learning devices they have, often shared among siblings or families.

Mobile-based learning, delivered via platforms such as YouTube, Khan Academy, and WhatsApp classrooms, enables students to access a range of educational resources, including short video lessons, AI-powered practice tools, peer and tutor feedback, language-specific content, and offline learning apps. These tools offer flexibility and accessibility, especially in low-resource settings. Despite widespread mobile phone ownership, affordability remains a

significant barrier, particularly for data usage costs, paid app subscriptions, and ongoing device maintenance, which can limit consistent access for many learners.

2. Reducing the cost of access

Governments, NGOs, and development partners must prioritise cost-reduction strategies to make mobile learning universally accessible. These strategies include zero-rating educational content by collaborating with telecom providers to exempt key learning platforms from data charges: subsidising internet access to offer free or low-cost mobile data to students in low-income households, and partnering with providers like Starlink to deliver affordable satellite-based internet in remote and underserved regions. Efforts should focus on distributing preloaded learning devices equipped with offline capabilities and aligned curriculum materials to support learners in areas with limited or no internet connectivity.

3. Inclusive mobile app ecosystems

Affordability must go hand in hand with relevance to ensure effective mobile-based learning. Educational apps should be free or freemium, available in local languages, and compatible with low-end devices to serve a broader user base. They should also be optimised for low-bandwidth environments, feature video compression and offline functionality, and align with national education standards to maintain curriculum relevance. Supporting local developers and creators in building such apps helps ensure that the content remains culturally appropriate, context-specific, and sustainable over time.

4. Policy measures for long-term affordability

Governments can adopt long-term policies to support digital education by implementing tax exemptions for educational devices and software, integrating mobile learning into national budgets and donor frameworks, and facilitating bulk procurement and distribution of smartphones or tablets to students. Digital inclusion should be embedded within broader universal service policies, ensuring that connectivity and access to mobile-based education are treated as public goods rather than private luxuries (Saputra et al., 2023).

Upskilling teachers for AI literacy

Teachers are the frontline agents of educational transformation. While artificial intelligence (AI) offers promising solutions for personalised learning, content automation, and administrative efficiency, its impact will only be fully realised if teachers are empowered, not sidelined. Ensuring that teachers are AI literate is crucial to achieving SDG 4 in an ethical, inclusive, and scalable way.

1. The role of AI literacy in teaching

AI literacy goes beyond basic digital competence. It requires that teachers understand how AI systems work and how they make decisions, interpret AI-generated learning analytics and feedback. They should use AI-powered tools for assessment, tutoring or content delivery. Teachers should recognise ethical concerns such as data privacy, algorithmic bias, and student autonomy. Without these skills, educators may either underuse AI or apply it in ways that could widen existing inequities or misguide learners (Sterling, 2024).

2. Integrating AI training into teacher education

To close this gap, ministries of education and teacher training institutions must embed AI literacy and digital pedagogy into pre-service teacher education and offer continuous professional development (CPD) focused on emerging EdTech tools.

They should provide micro-credentials and certifications that recognise tech-integrated teaching excellence and equip teachers with the confidence to critically evaluate AI resources and co-design their use in classrooms. These training initiatives should also include practical workshops, case studies, and peer-exchange forums where teachers can reflect on their experiences and share strategies.

3. Building a culture of human-tech collaboration

Effective AI integration hinges on a paradigm shift: moving from a model in which technology replaces teachers to one in which it amplifies their role. Teachers must be positioned as co-designers of AI-enhanced learning, using technology to tailor instruction, identify students at risk, foster deeper engagement, free up time for mentorship, creativity and socio-emotional learning. This requires not only training but also recognition and institutional support, such as time allowances for experimentation, incentives for innovation, and leadership opportunities in EdTech development.

4. Ensuring equity in access to training

Support mechanisms such as offline training modules, radio or TV-based upskilling programs, and mobile learning apps for teachers can play a crucial role in extending AI literacy and digital pedagogy to educators in regions with limited or no internet access. These alternative delivery methods are vital to ensure inclusiveness in professional development. Special attention must be given to rural teachers and educators in low-resource settings, female teachers who may encounter gender-based barriers to digital access, and those working in refugee camps or conflict-affected areas, where traditional training infrastructure is often unavailable.

Conclusion

Recap of key points

The present paper explored how the integration of artificial intelligence (AI) and youth-centric digital platforms can accelerate global progress toward Sustainable Development Goal 4 (SDG 4): Quality Education for All. It has identified the critical limitations of traditional education models, including standardisation, inaccessibility, and a disconnect from learners' real-world needs.

In contrast, today's digital-native students seek personalised, flexible, and mobile-first learning experiences that are increasingly delivered through platforms like YouTube, mobile apps, and AI-powered learning systems. When strategically deployed, these tools can deliver education that is scalable, inclusive, and responsive to the needs of diverse learners, including those in underserved or remote areas.

The paper has also emphasised that AI alone is not a panacea. Its benefits must be matched with robust infrastructure, policy support, ethical oversight, and teacher empowerment. With the right partnerships, especially among governments, the United Nations, EdTech innovators, and educators, technology can be transformed from a digital divide into a digital bridge.

Reframing SDG 4 as a flexible, scalable mission

Traditionally, SDG 4 has been interpreted through the lens of physical schooling and standardised metrics. This paper argues for a necessary reframing of viewing SDG 4 as a living, adaptable mission capable of evolving with technological and social shifts.

Education today must be flexible, meeting learners where they are physically, emotionally, and cognitively. It must also be scalable, capable of reaching billions without compromising quality. To be truly effective, education must be culturally contextualised, ensuring that global goals are realised through content and delivery methods that resonate locally. Equally important, it must be ethically governed, protecting learners from exploitation, profiling, or exclusion. This reframing transforms SDG 4 from a static checklist into a dynamic, inclusive ecosystem that supports lifelong, equitable learning in a digitally connected world.

Vision for the future: inclusive, accessible, human-centred education

The path forward must prioritise education that is not only technologically advanced but fundamentally human-centred. AI should be a partner to educators, not their replacement, and

digital platforms should serve as springboards for curiosity, connection, and growth, not mere content repositories.

In this vision, students learn from educators they relate to, in formats they enjoy, and at times that fit their lives. Teachers become guides and innovators, empowered, not constrained by AI. Governments and international bodies play a pivotal role by investing in equitable access and ethical safeguards, ensuring no learner is left behind. Learning becomes as mobile as the world we live in and as adaptable as the learners we serve.

Realising this vision will require bold leadership, global collaboration, and an unwavering commitment to equity, innovation, and sustainability. But if achieved, it will mark a monumental leap not only for education, but for humanity itself.

References

2019 GEM Report. (2023, January 23). 2019 Global Education Monitoring Report. 2019 GEM Report | Migration, Displacement and Education. Retrieved March 22, 2025, from https://gem-report-2019.unesco.org/

Abunamous, M. O., Boudouaia, A., Jebril, M., Diafi, S., & Zreik, M. (2022). The decay of traditional education: A case study under covid-19. Cogent Education, 9(1). https://doi.org/10.1080/2331186x.2022.2082116

Arruda, E. P., & Arruda, D. P. (2024). Artificial intelligence for SDG 4 of the 2030 agenda: Transforming education to achieve quality, equality, and inclusion. Deleted Journal, 2(2), 34. https://doi.org/10.62617/se.v2i2.34

D, P. K. T. (2024). Case Studies on Artificial Intelligence for Sustainable Education in 21 st Century. ResearchGate. Retrieved March 12, 2025, from https://www.researchgate.net/publication/378683480_Case_Studies_on_Artificial_Intelligence_for_Sustainable_Education_in_21_st_Century

Home - 2020 GEM Report. (2022, December 14). 2020 GEM Report. Retrieved March 22, 2025, from https://gem-report-2020.unesco.org/

Laricchia, F. (2024, June 12). Smartphones - statistics & facts. Statista. Retrieved April 2, 2025, from https://www.statista.com/topics/840/smartphones/#topicOverview

Manor, V. a. P. B. I. (2015, January 26). In Digital Diplomacy, A Narrowing Digital Divide-Part 2. Exploring Digital Diplomacy. https://digdipblog.com/2015/01/26/divide-2/

Mundial, G. B., De Población De Las Naciones Unidas, F., De Las Naciones Unidas Para El Desarrollo, P., & Unidas, N. (2016). Education 2030: Incheon declaration and framework for action: towards inclusive and equitable quality education and lifelong learning for all. https://www.semanticscholar.org/paper/Education-2030%3A-Incheon-declaration-and-framework-Mundial-Unidas/e0f670a590cbc4497ce449705281384dc494e5d0

Prince Ea. (2016, September 26). I SUED THE SCHOOL SYSTEM (2024) [Video]. YouTube. Retrieved February 26, 2025, from https://www.youtube.com/watch?v=dqTTojTija8

Sahney, S., Banwet, D., & Karunes, S. (2004). A SERVQUAL and QFD approach to total quality education. the International Journal of Productivity and Performance Management/International Journal of Productivity and Performance Management, 53(2), 143–166. Retrieved April 26, 2025, from https://doi.org/10.1108/17410400410515043

Saputra, I., Astuti, M., Sayuti, M., & Kusumastuti, D. (2023). Integration of Artificial intelligence in Education: Opportunities, Challenges, Threats and obstacles. A literature review. Indonesian Journal of Computer Science/Indonesian Journal of Computer Science, 12(4). Retrieved March 29, 2025, from https://doi.org/10.33022/ijcs.v12i4.3266

Sterling, S. (2024). Learning and sustainability in dangerous times. Retrieved April 18, 2025, from https://doi.org/10.2307/jj.13473649

Top 100 education YouTube creators by subscribers - Social Blade. (2025). Retrieved April 25, 2025, from https://socialblade.com/youtube/lists/top/100/subscribers/education/global

Transforming our World: The 2030 Agenda for Sustainable Development. (n.d.). https://sustainabledevelopment.un.org/post2015/transformingourworld/publication

Wettlaufereid. (2017, February 9). The digital divide and how we're bridging it. EID100. Retrieved April 25, 2025, from https://wettlaufereid100.wordpress.com/2017/02/09/the-digital-divide-and-how-were-bridging-it/

Will Our Educational System Keep Pace with AI? A Student's Perspective on AI and Learning. (n.d.). EDUCAUSE Review. https://er.educause.edu/articles/2024/1/will-our-educational-system-keep-pace-with-ai-a-students-perspective-on-ai-and-learning

World Bank Open Data. (n.d.). World Bank Open Data. Retrieved April 02, 2025, from https://data.worldbank.org/indicator/IT.NET.USER.ZS?end=2023&start=2023&view=map&year=2023