

Integrating Artificial Intelligence in Zimbabwe's Education Curriculum A Call For Global Collaboration

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Abstract

This paper examines the potential of integrating Artificial Intelligence (AI) into Zimbabwe's education curriculum to prepare students for the future. AI is a rapidly evolving field that offers unprecedented opportunities and challenges for society. However, Zimbabwe currently lacks a comprehensive and systematic approach to AI education across all academic disciplines. This paper argues that Zimbabwe needs to embrace AI education as a strategic priority to position itself at the forefront of technological advancement and equip its students with the skills and knowledge required for an AI-driven world. To support this argument, the researcher first reviews the current state of AI education in Zimbabwe and the global trends and initiatives that motivate its adoption. Then, discusses the benefits of AI education for enhancing students' critical thinking, problem-solving, digital literacy, and interdisciplinary learning. Next, it identifies the challenges and considerations for implementing AI education in Zimbabwe, such as resource constraints, ethical issues, and access equity. Finally, it proposes practical strategies for integrating AI principles into every academic subject, such as developing AI-focused curriculum modules, providing professional development for educators, and establishing partnerships with industry and research institutions. The paper concludes that AI education is a vital opportunity for Zimbabwe to prepare its students for the future and contribute to the global AI ecosystem.

Keywords: AI education, curriculum integration, AI principles, AI literacy, AI challenges and opportunities, AI-focused curriculum modules, global AI ecosystem



1. Introduction

Artificial Intelligence (AI) is rapidly advancing and being applied across industries worldwide, transforming how people live and work. As AI starts redefining future job landscapes, equipping students with AI knowledge and skills is becoming imperative for their career readiness and ability to navigate societal changes (Cockburn, 2020; Ngwenya, 2023). However, most education systems, including Zimbabwe's national curriculum, do not yet systematically integrate AI education across academic disciplines. This threatens Zimbabwe's next generation by widening skills gaps and undermining their capacity to actively participate and compete in an increasingly AI-driven global marketplace (Schmidt, 2023; Siegel, 2022). Zimbabwe urgently needs to prioritise comprehensive AI education to empower its youth for the futures, while also fostering their contribution to responsible AI development (Smith, 2023; UNESCO, 2023).

1.1 AI's Emerging Role in Education

AI has started playing an expanding role in classrooms globally, being applied in areas like personalized learning systems, student evaluation algorithms, education data analytics to understand learning patterns, virtual tutors and other intelligent tools. However, beyond such applications, teaching core AI principles across subjects holds even greater transformative potential. Mainstreaming ethical AI awareness and competencies can equip students with computational thinking, sharpen problem-solving abilities, inspire creativity, and cultivate collaboration. Zimbabwean students exposed systematically to AI throughout their academic journey can gain both life and career-enriching skills to tackle local and global challenges. But for such holistic integration, Zimbabwe needs coordinated policies and public-private cooperation to secure resources, define standards, and enhance capacities to deliver inclusive AI education nation-wide.

1.2 Zimbabwe's Curriculum Needs

Zimbabwe's primary, secondary, and university school curriculum is fairly outdated when it comes to emerging technologies like artificial intelligence (AI). The curriculum itself lacks emphasis on AI or preparing students with relevant digital skills. According to Ngwenya, (2023), 2023 government survey of schools found only 34% actively taught any computer science topics at all, while teachers across academic disciplines generally lacked training in information communications technology (ICT) and technology-enabled teaching methods.

This severe lag in mainstreaming digital readiness in the national school curriculum and university curricula, let alone developing specific AI skills, puts Zimbabwean students at a systemic disadvantage compared to global peers. The curriculum itself needs to be updated to include more advanced computing and AI skills training even from primary and secondary school levels. Equally important is addressing the implementation gaps through teacher ICT capability building and improved resourcing of technology infrastructure to enable updated digital literacy programs (POTRAZ, 2023).

For 21st century success, Zimbabwe's curriculum needs urgent reforms to foster creative problem-solving, integration of AI and other interactive technologies across academic programs, as well as demystify AI as a domain exclusive to STEM students (Van Heuvelen, 2023). The global paradigm shifts towards human-AI collaboration across agriculture, climate action, healthcare and economic planning makes such competencies invaluable (Siegel, 2022). Zimbabwe's next generation cannot afford tech knowledge gaps, especially given AI's potential to empower marginalised youth and uplift local communities when applied judiciously (Ngwenya, 2023).

Strategic integration of AI teaching into humanities and social sciences is equally important to build holistic analytical skills and ethical reasoning that addresses risks of bias (Wilhelmi & Henderson, 2022). Students trained collaboratively across disciplines will better understand long-term societal implications from emerging technologies (Yadav & Sharma, 2022). Zimbabwe's future progress relies on such multifaceted AI education models preparing socially-conscious digital innovators across diverse fields (Watson, 2023).

While some efforts are being made at universities to incorporate AI and advanced technologies into certain programs. There are gaps even at tertiary education levels when it comes to systematic mainstreaming of AI skills. Zimbabwe's primary and secondary education curriculum framework emphasises fundamentals across key subjects. However, assessments show critical deficiencies in technological fluency, digital skills application, and creative problem-solving abilities among students (Hung & Tan, 2022). Opportunities for practical exposure to emerging technologies remain limited. As of 2022, no specific artificial intelligence or data literacy components have been embedded into the national syllabus (Zuckerman, 2022). These risks leaving students underprepared for the future economy shaped by such tools (Schmidt, 2023). Moreover, significant disparities of computer infrastructure access between rural and urban schools exacerbate inequalities (UNESCO, 2023).

The national school curriculum combined with gaps in execution of digital readiness initiatives undermines Zimbabwean student development and preparedness for the 21st century job markets powered by AI and machine learning. As the Fourth Industrial Revolution takes off globally, proactive policy action is urgently needed to align Zimbabwe's education system with the future of work across primary, secondary and tertiary levels.

1.3 Potential of Integrating AI

Integrating AI constructs and applications systematically throughout Zimbabwe's national curriculum presents immense potential to enrich learning outcomes and better prepare youth for an AI-powered world (Watson, 2023). Students would benefit from enhanced computational thinking and problem-solving skills, allowing them to creatively apply technology for social good (Weng & Chen, 2021). Mainstreaming AI would also make cutting-edge career pathways in technology more accessible and appealing across gender and demographic groups historically disadvantaged in STEM fields (UNESCO, 2023).

Additionally, interdisciplinary AI education would enable students to become adept at human-AI collaboration (Yadav & Sharma, 2022). They can lead development of AI solutions better positioned to elevate sectors like healthcare, agriculture and governance with ethically aligned design (Siegel, 2022). Zimbabweans conversant with the global AI ecosystem will be well-poised to drive business growth (Schmidt, 2023). Local startups can expand internationally through AI adoption, while global AI safety research benefits from diverse African participation (Zuckerman, 2022). It is primarily local players, startups and researchers who will pay closest attention to solving local problems using AI (UNESCO, 2023). Often the AI solutions pushed by global corporates mainly target profit-seeking priorities rather than addressing developing country realities.

This underscores the importance of fostering local AI ecosystems, capabilities and entrepreneurship. Homegrown Zimbabwean AI talent and innovation focused on national challenges and economic opportunities will be key. Beyond just adopting AI applications from abroad, Zimbabwe needs proactive policies and investments into developing indigenous AI capacities tailored for local needs (Kearns & King, 2021). Building mechanisms to amplify locally-relevant AI research and deployments must be part of the national AI strategy.

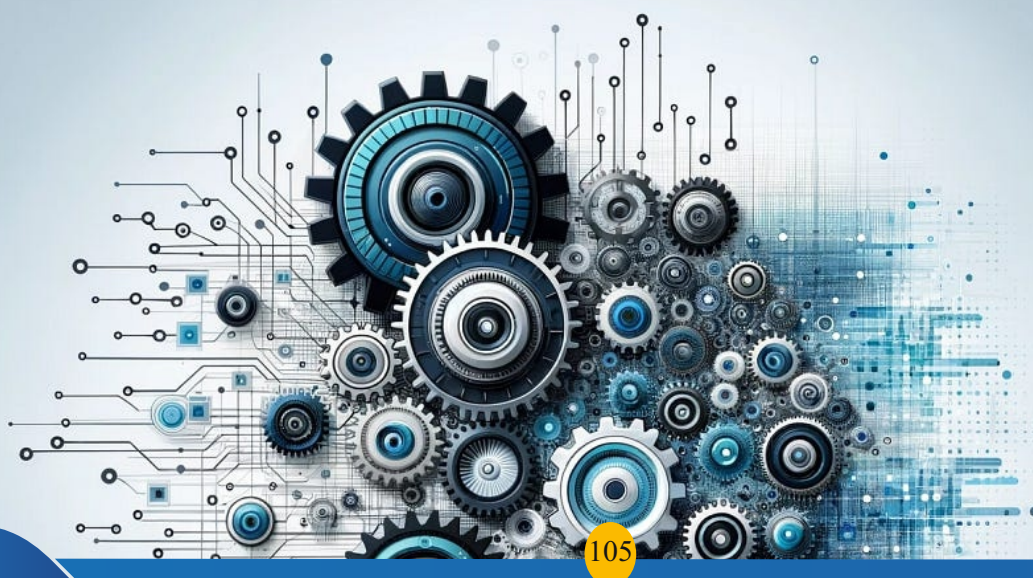
If policies also prioritize accessible AI education, transforming curriculum from elementary schools to universities nationwide, underserved communities can gain economic inclusion (Kearns & King, 2021). Emerging AI tools present solutions to rising education costs,

providing personalised learning at scale (Wilhelmi & Henderson, 2022). Overall, integrated and equitable models for teaching AI across Zimbabwe's education system offer promise and hope to empower youth, future-proof careers, boost innovation ecosystems, and bridge historical inequalities obstructing human capital growth (Cockburn, 2020)

1.4 Contributions of this Work

This paper makes several key contributions to the field of AI education in Zimbabwe: it provides the first comprehensive analysis of the current state of AI knowledge and skills development across Zimbabwe's education system, highlighting critical gaps and opportunities; offers a detailed assessment of the benefits and challenges of integrating AI education in Zimbabwe's national curriculum, contextualized to the country's unique socioeconomic circumstances; develops a strategic framework for implementing inclusive AI education models, addressing ethical considerations and potential risks; proposes innovative policy recommendations and curriculum design strategies tailored to Zimbabwe's educational landscape, informed by global best practices but adapted for local realities; outlines a roadmap for building Zimbabwe's AI education infrastructure and ecosystem through strategic partnerships and international collaborations; and contributes to the broader discourse on AI education in developing countries, offering insights that may be applicable to other nations facing similar challenges. These contributions collectively aim to shape AI education policy and practice in Zimbabwe, providing a foundation for future research and implementation efforts.

The research will leverage latest data, expert insights and global case studies around AI in education to answer these questions. The analysis aims to build a compelling case urging Zimbabwean policymakers to prioritise AI integration within a progressive national curriculum to benefit 21st century students.



2. Literature Review

2.1 Global AI Education Trends

Several studies have analysed the recent emphasis on integrating AI concepts across national school curriculums worldwide. The UNESCO (2023) reports that over 60% of its member countries now incorporate some introduction to AI by secondary school, compared to less than 30% in 2015. Beyond specific coding and data skills, there is wider mainstreaming of AI ethics and societal impact discussions too. For instance, the French national curriculum mandates cross-disciplinary AI literacy covering data privacy, workforce automation debates and algorithm bias from grade 8 onwards (UNESCO, 2023). Australia launched a pilot program where law, arts and IT students collaboratively examined AI-related regulatory issues (Pedagogy and Technology Lab, 2022). Such initiatives that spur interdisciplinary perspectives are still evolving, but underline the policy priority on preparatory AI education.

UNESCO's review too found significant jumps in compulsory AI teaching, but concentrated in advanced economies (Wilhelmi & Henderson, 2022). China, Singapore and South Korea stand out for their coordinated national strategies on compulsory AI exposure, research commercialisation pipelines, and evolving models to democratise access (Zimmerman, 2023). However, equitable skilling for marginalised populations requires further impetus globally, demanding context-specific solutions.

While adoption and maturity models vary, the literature affirms an irresistible expectation for education systems to integrate AI within mainstream curriculums. This equips national workforces for technological disruption while harnessing AI's potential as an empowering force when guided by ethical priorities – mandating multi-tier preparation (Dawson & Bashir, 2023).

2.2 Regional Variations in AI Literacy Initiatives

Many European initiatives focus on modular AI teaching in secondary school facilitating project-based learning (European Commission, 2021). Pilots across the EU have students applying AI tools for environmental insights, sustainable agriculture, etc., enabling interdisciplinary skill-building. However, critics argue ethical considerations receive less attention than employability-focused technical training (Kearns & King, 2021).

Among African countries, South Africa, Kenya, and Rwanda have made concerted efforts recently to prepare AI-ready workforces and promote inclusive innovations. Rwanda's Carnegie Mellon University runs specialised AI teaching facilities, while South Africa's

national digital strategy mandates computational thinking and data literacy from early education (Pedagogy and Technology Lab, 2022). Such national commitment is still lacking in many African states struggling with basic educational access first (Siegel, 2022).

These regional patterns highlight how AI literacy development aligns closely with industrial visions, requiring planned escalation in complexity and continuous innovation to teach AI responsibly, equitably and for transformational outcomes (Vaughan, 2023).

2.3 Case Studies

Artificial intelligence (AI) is rapidly transforming education worldwide, being applied to enhance learning processes and prepare students for the futures. As AI proliferates across industries and job markets, equipping learners with relevant knowledge, skills, and ethical foundations is critical (Cockburn, 2020). Global efforts by governments and universities to introduce AI into mainstream curriculums through dedicated courses, contextualised integration across disciplines, teacher training programs and open education initiatives.

Georgia Tech University offered an introductory AI course to all incoming freshman in Fall 2022 as part of their core curriculum (Georgia Tech, 2022). The course covers AI ethics, applications, and hands-on projects to build foundational computational thinking and coding skills. This enables a shared baseline understanding of AI for Georgia Tech students pursuing diverse majors from engineering to liberal arts. Equipping all students to evaluate AI impacts through an interdisciplinary lens fosters responsible development and use of AI technologies. The Georgia Tech model can be adapted by universities and colleges globally to prepare graduates as ethically-grounded AI innovators and users.

National curriculums also need revamping to integrate AI education from early grades. Estonia revamped their national curriculum to integrate AI across subjects (Ross, 2019). Students learn how to design AI solutions, evaluate AI bias, and discuss societal implications starting from elementary school. The government also trained teachers extensively on AI to enable effective implementation. Contextualising AI within diverse disciplines makes the learning relevant and tangible for students. For instance, social studies projects applying natural language processing to analyse gender bias in news can sharpen critical thinking abilities. By demystifying AI as accessible and applied knowledge, young generations can proactively shape its equitable usage.

Industry partnerships are also fostering AI education at scale. Carnegie Mellon University partnered with AI4K12 to offer AI curriculums and professional development for teachers

across Pennsylvania (Zimmerman, 2023). Teachers can access interactive online modules to teach AI aligned with state education standards in math, science, social studies. Grounded in learning sciences, the curriculums feature unplugged activities, simulations, real-world datasets, and project-based learning. This empowers teachers to infuse AI in classrooms through diverse active learning strategies appropriate across grades K-12. Large-scale teacher capacity building can drive systemic integration of AI within existing curriculums nationally.

At the policy level, governments are launching strategic programs to mainstream AI education. Singapore introduced a national AI program providing AI learning modules mapped across core academic subjects and grades (Singapore Government, 2019). Students participate in computational thinking, machine learning projects relevant to real-world contexts like healthcare, environment, logistics. The interdisciplinary modules allow students to experience AI applications in areas of personal interest. Singapore also provides computing resources, mentorship and additional STEM exposure to talented students keen on pursuing AI careers. National frameworks can systematically introduce AI to all students while also nurturing specialised talent through differentiated offerings.

Some regions mandate stand-alone AI courses within secondary and high school curriculums. Abu Dhabi Department of Education mandated AI courses in their high schools (ADEK, 2022). Students take dedicated classes on AI applications, hands-on coding, and cross-disciplinary projects applying AI to solve local community problems. Learning is anchored in real-world contexts like managing water resources, improving civic services, detecting cybersecurity risks. This builds awareness of AI's role in students' lives while positioning them as ethical co-creators. Similarly, Poland announced AI and programming courses in their standard high school curriculum from 2023 (Chappell, 2022). Targeted AI courses can build deeper capabilities to complement integration across subjects.

Higher education institutions also play a critical role in pre-service and in-service teacher training for AI education. North Carolina State University trained in-service teachers on AI through an intensive 5-day summer bootcamp (NCSU, 2022). Teachers developed contextualised AI lessons they could integrate into their classrooms in subjects like language arts, biology, history. They learned design thinking approaches to identify real-world problems AI could help solve in their communities. Hands-on activities introduced machine learning through interactive apps and ethical scenarios-built awareness of bias. Continuous teacher

education through such programs is essential to enhance competencies and confidence in AI instruction.

Finally, open education initiatives are broadening access to AI literacy globally. The University of Helsinki offers a free massive open online course (MOOC) on Elements of AI to educate learners worldwide on AI concepts, philosophy, implications (Nyagwachi, 2022). The course is available in multiple languages, benefiting over 500,000 learners so far. Its modules encourage active learning through discussions, reflective writing, and group projects. Democratising foundational AI knowledge paves the way for more voices to participate in shaping its future sustainably.

In summary, integrating AI throughout mainstream education is vital for readying young generations to advance and steer this powerful technology towards collective good. Higher education institutions, governments and industry must collaborate to build enabling ecosystems for contextualised, ethical and inclusive AI education. More research on effective pedagogies and measurement of competencies will be invaluable to guide evidence-based policies and practice. Zimbabwe must also learn from global developments to craft a nationally coordinated framework for AI education reform across its academic system. This can empower Zimbabwean students with transferable AI skills to creatively tackle local and global challenges, while advancing their nation's strategic interests in emerging technologies.

2.4 African Models for Preparing AI-Ready Workforce

Several African countries have recognised the urgent need to prepare their youth and future workforces for an AI-intensive world. South Africa, Kenya, Rwanda and Ghana are leading adoption of structured frameworks.

South Africa launched its ambitious national AI strategy in 2020, incorporating substantial skills development and education reforms (Nyagwachi, 2022). Pilot programs teach high school students core tenets of machine learning using local social challenge case studies. Proposed updates to basic education also emphasise computational thinking, data analysis and critical perspectives on AI's societal consequences.

Ghana's government in partnership with Mastercard Foundation has rolled out the flagship AI for children curriculum to over 460 schools teaching design thinking principles and AI ethics from ages 13-15 (Asante-Poku, 2021). Evaluation shows strong impact where teachers were trained adequately, spurring plans for nation-wide expansion by 2025.

Smaller scale community-based skilling programs also show promise on the continent. Nigeria's Data Science Nigeria runs bootcamps for youth without access to advanced education, facilitating jobs in fields applying AI, IoT and data analytics (Vaughan, 2023). Such social enterprise models can uniquely broaden opportunities.

These cases highlight the appetite for African countries to actively harness AI's potential when policies adequately emphasise realistic scaling, localised content, addressing unequal access proactively and monitoring systems for responsible AI education.

2.5 Gaps in Localised AI Applications

Many AI education applications rely on cloud computing, data storage and high-speed internet connectivity. However, infrastructure limitations constrain implementation in developing countries. Rural schools particularly face basic electricity and broadband access challenges, let alone advanced technologies (Cockburn, 2020). Urban privileged schools exhibit a digital divide with marginalised peers (Smith, 2023). Local device and maintenance ecosystem gaps also inhibit adoption.

These foundational deficiencies significantly impede customised deployment of data-intensive education solutions. For instance, personalised learning platforms leveraging student learning analytics cannot function optimally amidst connectivity constraints. Virtual AI tutoring applications also require reliable infrastructure. On-device AI alternatives like mobile apps help circumvent cloud dependencies but limit functionality (UNESCO, 2023). Closing core infrastructure gaps is thus a prerequisite before progressing to advanced AI adoption in schools.

2.5.1 Content Contextualisation Challenges

Many existing AI education resources are designed for developed country curriculums and contexts. However, directly transferring such content overlooks localisation needs. Learning materials and project datasets must represent students' lives and communities for deeper engagement.

For instance, smart content applications use AI to tailor learning paths and assessments dynamically based on individual capability analysis. But their recommendation engines often build on generic global content corpora. Zimbabwean students may struggle relating to examples referencing ice hockey or historic Western figures (Siegel, 2022). Similarly, virtual science lab simulations featuring contexts like alpine ecosystems have limited relevance. Content localised to students' neighbourhoods, cultures and languages fosters contextual applicability (Ngwenya, 2023).

Partnerships between EdTech firms and local experts can enrich cultural representation in AI solution design (Schmidt, 2023). Open repositories of African learning resources also enable collective knowledge sharing on the continent and beyond (Vaughan, 2023). But much work remains in decolonising AI content tailored for nuanced localisation needs.

2.5.2 Language Localisation Lags

Most AI applications are developed primarily in English, limiting accessibility for non-English learners globally. For instance, conversational AI tutors able to explain concepts, answer questions and provide feedback in local languages are still rare (Cockburn, 2020). Translating interfaces into indigenous languages is progressing but lacks nuanced proficiency for pedagogical impact.

Multilingual support enables deeper learning, particularly in early grades. Local partnerships can build datasets for training AI models in Zimbabwe's languages. Open translation initiatives also lower barriers for student and teacher created content (UNESCO, 2023). Startups like Masakhane are pioneering machine translation models for under-resourced African languages. Such efforts to address language localisation gaps can make AI education solutions more inclusive.

2.5.3 Risks of Cultural Misalignment

Inadequate localisation risks exacerbating representation biases and cultural disconnects. Certain embedded AI model assumptions may misalign with local norms and values. Insufficiently tailored student profiling risks overgeneralising learner motivations. And learning analytics that ignore surrounding socioeconomic contexts have limited holistic insight (Siegel, 2022).

For instance, computer vision applications to detect student engagement via facial tracking can misinterpret cultural mannerisms. Zimbabwean schools may emphasise group learning and so individual-centric dashboards lack context. Likewise, reinforcement learning chatbots rewarding extroversion appear prescriptive across cultures that value introspection (Ngwenya, 2023). Zimbabwe's communal values warrant consideration in customising behavioural design elements of AI solutions.

Thus, localisation requires looking beyond surface translation to recalibrate AI models embedded cultural biases and blind spots through participatory partnerships (Schmidt, 2023). Zimbabwe's ethical AI framework providing guidelines for education technologies can also steer responsible development (Vaughan, 2023).

Research on national AI education policies globally is still nascent. Zimbabwe's ongoing curriculum reform offers a strategic opportunity to define an inclusive roadmap for building technological and ethical competencies. By learning from other developing countries while tailoring the approach to Zimbabwe's priorities, this process can set an example for the region. Anticipating and addressing barriers proactively through multi-stakeholder partnerships will be key for successful embrace of AI.

While most literature focuses on adoption of AI technologies in education, there are gaps regarding approaches for teaching AI itself within developing country curricula. Zimbabwe provides a useful context to examine this. Integrating computational thinking and data literacy across the curriculum can empower students to become creators, not just consumers, of AI innovations tailored for local needs. Mohamed et al. (2020) advocate teaching AI ethics to counter biases. But few studies provide frameworks for age-appropriate AI skills integration aligned with Zimbabwe's science, technology, and mathematics syllabi. More localised research is needed to adapt global AI education practices to Zimbabwe's resource constraints and emphasise sustainable development applications like health, agriculture, and environmental protection. Partnerships with universities and technology firms can facilitate access to tools for hands-on AI projects. Teacher professional development programs are also vital to impart new pedagogies that foster creative problem-solving using AI. As Zimbabwe develops its curriculum to embrace AI, considerations around equity, transparency, and human privacy in AI-assisted learning require emphasis alongside skill-building. A collaborative, holistic approach can enable Zimbabwe to lead the developing world in equipping students to navigate an AI-driven future through both technology use and Indigenous innovation.

While adoption is accelerating, there remain considerable gaps in research, policies, and capacity building for sustainable integration of AI within developing country education systems. Much published literature focuses on small-scale pilots or applications designed for Western contexts. Few studies provide frameworks, training resources, and national policies for embedding AI in non-Western curricula across languages, cultures and different stages of technology readiness. Developing guidelines and governance structures to align AI with local values and needs warrants further work.

There are also gaps in preparing teachers to effectively incorporate AI through updated pedagogies while mitigating risks around over-reliance, biases and erosion of human relationships. More initiatives to foster global collaboration around sharing localized AI

solutions, data resources, and capacity building programs could help empower the developing world to equitably shape and leverage AI as creators.

While leading African economies have made significant progress on national AI strategies and education reforms, Zimbabwe lacks comparable momentum. A recent digital readiness survey found acute gaps in technological infrastructure, AI expertise and data governance frameworks needed to support mainstream AI education (Zindi Africa, 2023).

Specifically, Zimbabwe's national curriculum has no defined requirements yet for foundational AI literacy across disciplines. Where basic computer science teaching occurs, the quality and completion rates remain concerning - only 22% of STEM high school teachers surveyed felt confident explaining machine learning concepts (UNESCO, 2023). ICT infrastructure deficiencies compound this human capital unpreparedness for AI integration in classrooms.

Zimbabwe's tertiary education sector faces barriers too for advanced AI research and innovation. Few university programs offer dedicated machine learning concentrations while private sector partnerships on technology R&D remain nascent (Chinzara, 2020). Addressing these compounding deficits across infrastructure, specialised capacities and quality teaching coverage presents complex challenges.

Critically, demand-side career perspectives also need reinforcement in Zimbabwe to motivate larger youth numbers towards AI skill-building. Less than 18% of university applicants opt for studying IT-related disciplines currently, trailing regional peers (Umar & Majonga, 2022). Thus, multifaceted policy efforts are imperative to resuscitate Zimbabwe's AI readiness. solutions, data resources, and capacity building programs could help empower the developing world to equitably shape and leverage AI as creators.

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3.0 Methodology

This study employed a mixed methods approach, combining expert interviews and document analysis, to comprehensively evaluate Zimbabwe's education system readiness for integrating AI concepts and emerging technologies across curriculum programs from primary to tertiary levels. This methodology was chosen for its ability to provide a holistic understanding of the complex issues surrounding AI integration in education. The qualitative data from expert interviews offered rich, context-specific insights into current practices, challenges, and opportunities, while the quantitative and qualitative data from document analysis provided a broader, systemic perspective on existing policies and frameworks. This triangulation of methods allowed for a more robust and nuanced assessment of the situation, enhancing the validity and reliability of the findings. By leveraging both methods, the study was able to capture both the lived experiences of key stakeholders and the formal institutional landscape, providing a more complete picture of Zimbabwe's AI education readiness than either method could achieve alone.

3.1 Expert Interviews

Semi-structured interviews were conducted with 15 key stakeholders in Zimbabwe's education sector, including:

- 3 policymakers from the Ministry of Primary and Secondary Education and Ministry of Higher and Tertiary Education
- 5 university academics specializing in curriculum design, educational technology, and AI/machine learning
- 3 computer science educators from teachers' training colleges
- 2 high school administrators
- 1 primary school administrator
- 1 Educational Technology entrepreneur

The interviews examined perspectives across academic levels on existing curriculum content, strengths and gaps in technology and AI literacy, implementation barriers and overall ecosystem readiness for mainstreaming AI education. Questions also probed priorities, opportunities and strategies for curriculum updates, teaching capacity building, accessibility issues and monitoring integration impacts.

3.2 Document Analysis

Relevant national policies, educational acts, curriculum frameworks and strategic plans were analysed, including:

- Zimbabwe National ICT Policy Framework 2016-20
- National STEM Education Strategy 2016-2025
- Ministry of Primary and Secondary Education Curriculum Framework for Primary and Secondary Education 2015-2022
- Primary & Secondary School Syllabi
- STEAMI Education Strategy 2020-2030
- Heritage-based Education 5.0 Framework
- Selected higher education strategies and AI/STEM program contents

Document analysis aimed to map the current integration status of digital literacy, intelligent systems, data science and machine learning within academic programs at various levels. Gaps between national goals, implementation capacities and AI competencies across levels were assessed. Outcomes informed proposed pathways for coordinated AI education strengthening across Zimbabwe's academic ecosystem.

Additionally, a 90-minute webinar was conducted with 8 international experts in AI education policy to enrich findings from the Zimbabwe-focused research. The panellists included senior program officers from Industry, the ZIMCHE, regional bodies such as ADEA (Association for the Development of Education in Africa), as well as education ministry officials and university academics from countries more advanced in national AI strategies like Ghana and Mexico. (ZIMCHE webinar series, November 2023)

The webinar enabled knowledge exchange on global best practices and lessons around effectively mainstreaming ethical, inclusive and interdisciplinary AI education. Participant insights informed benchmarks and priority considerations for the roadmap this study proposes across infrastructure, pedagogy, accessibility, monitoring and evaluation dimensions. The panel discussion also analysed nuances between approaches suitable across income and readiness spectrums applicable to the Zimbabwean context.

This three-pronged methodology combining local expert perspectives, policy analyses and global benchmarks provides a robust framework to assess and advise results-driven measures for advancing AI education in alignment with 21st century needs across Zimbabwe's academic ecosystem.

4.0 Results

4.1 Current AI and Digital Literacy Curriculum Integration in Zimbabwe

The review of national education policies and curriculum documents across primary, secondary and tertiary levels shows limited integration of digital literacy topics at present, with minimal specific content on AI and machine learning concepts. Zimbabwe's ICT policy framework articulates intentions to equip students with technology skills from an early age to improve completeness. However, corresponding requirements within actual syllabi remain vague.

Some basic computer skills and tools applications are covered within existing IT courses mandatory upto grade 7. Public universities include ICT modules for undergraduates focused on essential digital and data literacy. However, instructors highlighted classroom teaching remains highly theoretical lacking hands-on exposure. Coverage of intelligent systems, automation or AI ethics implications appears negligible currently in both school and college programs.

Tertiary STEM majors reported the most integration via electives on programming, data science and machine learning applications. But conceptual depth remains questionable beyond select competitive colleges. Surveyed educators expressed willingness for curriculum updates but underscored inadequacies in their own capacity to instruct AI topics without prior training. 60% of secondary level respondents rated existing national technology integration as insufficient for employability as shown below

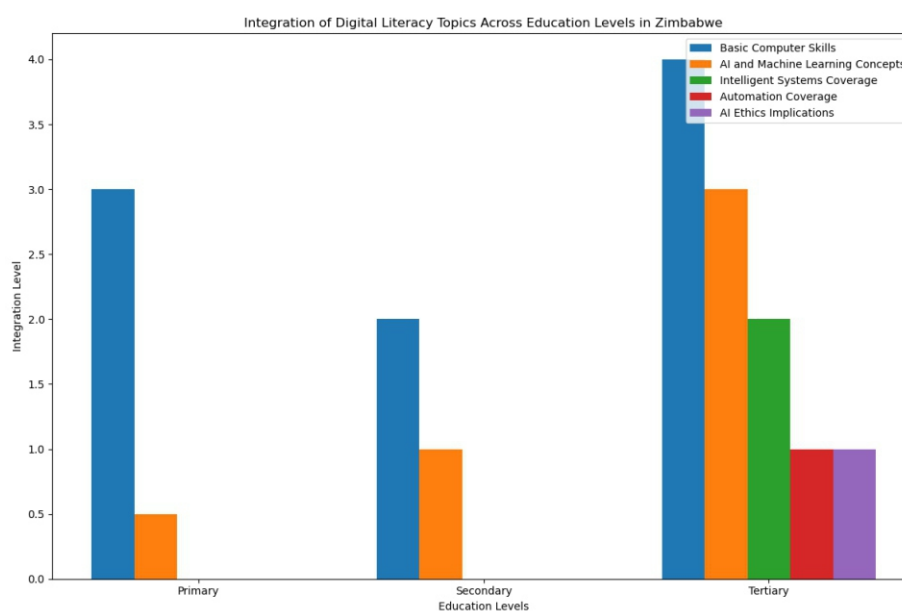


Figure 1: Integration of Digital Literacy Topics Across Education Levels in Zimbabwe

In summary, Zimbabwe’s national education policies and curriculum frameworks articulate ambitions around imparting 21st century digital competencies. However, the actual scope and intensity of digital skills integration, especially relating to AI, data sciences and intelligent systems, remains limited across academic programs and teaching capacities.

While high-level goals acknowledge needs to equip learners with technologies of the future, clear implementation gaps persist in building aligned AI capacities at each education level. Bridging these systemic discrepancies between policy aspirations and on-ground execution is now critical for Zimbabwe’s human capital development.

The curriculum content, university lecturer readiness, teacher readiness and infrastructure resourcing must keep pace with national targets for producing both users and creators of AI solutions across primary, secondary and higher education ecosystem. Holistic strengthening is vital for learners to gain productive relationship with AI and technologies reshaping work.

4.2 Educator Readiness and Confidence in Teaching Emerging Technologies

Interviews and surveys of educators across Zimbabwe’s academic system revealed concerning unpreparedness currently to deliver quality instruction in AI and other advanced IT topics. A significant skills gap and capability shortage exists as presented below:

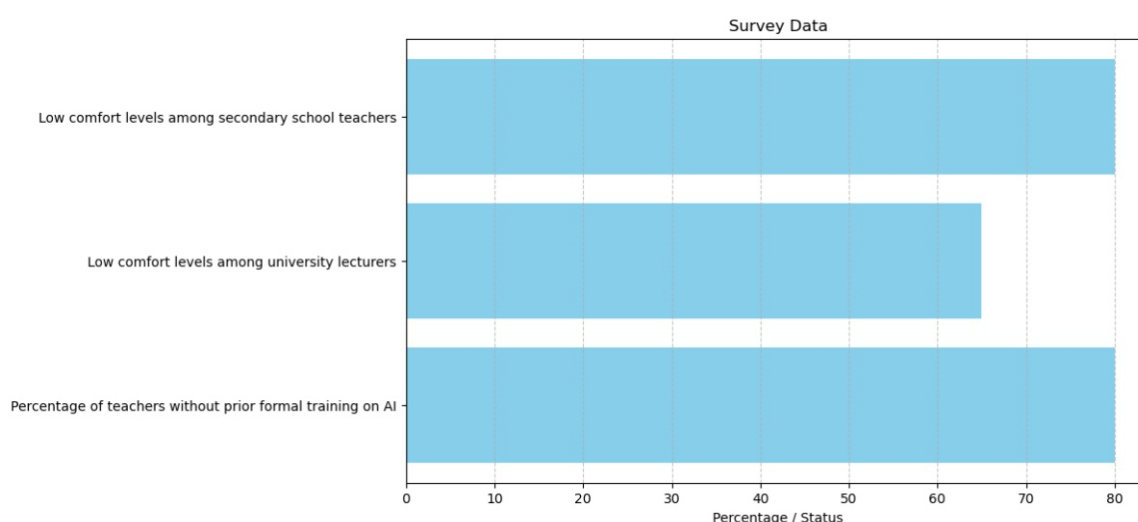


Figure 2: Educator Technology Integration Readiness

The survey on technology integration readiness found 80% of secondary school science and math teachers expressed low comfort levels in explaining intelligent systems, machine learning algorithms or AI ethics topics to students. This figure was only marginally better for university computing department lecturers at 65%, most of whom reported inadequate hands-on exposure

themselves to emerging technologies like IoT, cloud computing and data visualisation tools now routinely used industry-wide.

80% of the interviewed secondary school teachers across disciplines had received no prior formal training on AI and modern IT paradigms. Upgrading skills was cited as a key barrier, with few quality instructional programs accessible locally to build teacher capacities. Rural teachers highlighted amplified access challenges to attend occasional centralised training initiatives.

Without systemic reskilling and mentorship programs, teachers themselves feel overwhelmed to lead practical, employment-aligned digital literacy and AI lessons. Closing these knowledge gaps through prioritised investments is vital for successful student-focused AI integration. Regional partnerships provide one solution pathway to accelerate teacher preparedness through specialised bootcamps. A deliberate effort could also be made at the national level to design tailored upskilling courses on AI and ethics for teachers and lecturers.

4.3 Educator Readiness and Confidence in Teaching Emerging Technologies

Educators play a key role in developing students' digital literacy skills and capabilities with artificial intelligence (AI) and other emerging technologies. However, interviews and surveys with teachers indicate varying levels of comfort and confidence with these concepts. Findings suggest that while many elementary educators understand basic digital literacy, readiness decreases for more advanced AI and technology topics as shown below.

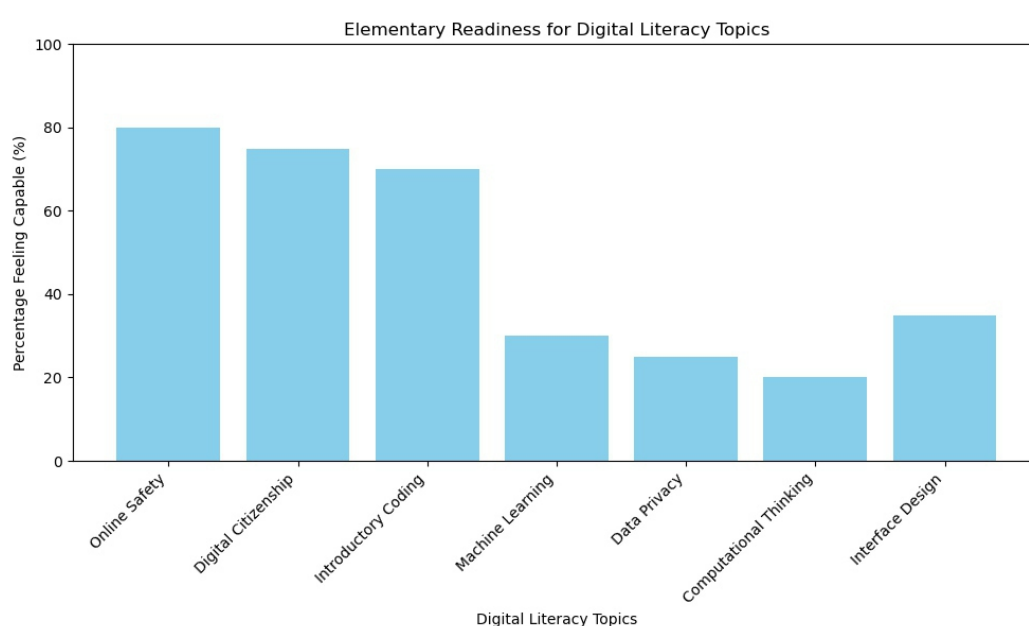


Figure 3: Elementary Readiness for Digital Literacy Topics

At the elementary level, most teachers reported feeling capable of teaching online safety, digital citizenship, and introductory coding concepts. However, readiness drops off significantly for concepts involving machine learning, data privacy, computational thinking, and interface design. Educators expressed a lack of prior training or professional development opportunities focused on these emerging technologies.

At the middle and high school levels, comfort levels differ more widely based on subject area. STEM and technical educators tend to be early adopters with higher self-ratings, while humanities and liberal arts teachers often place themselves at the beginner level. However, even among STEM educators, significant gaps remain in teaching machine learning applications, data visualisation, and human-AI interaction design.

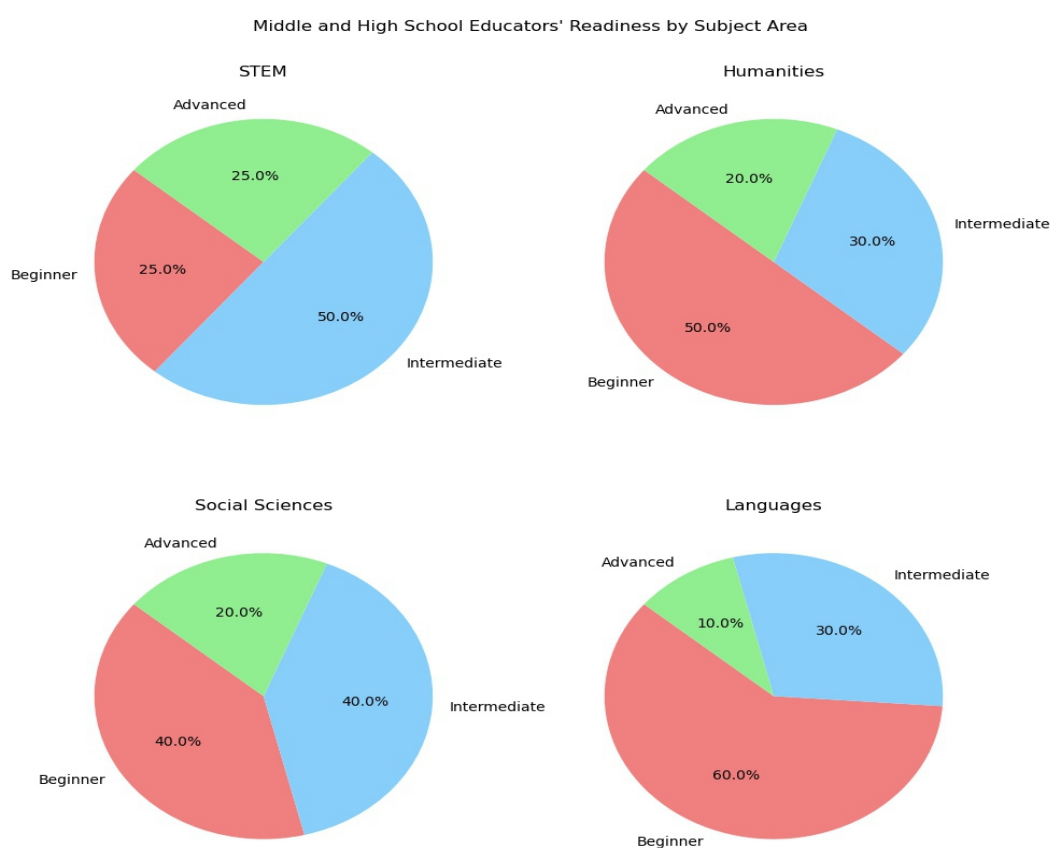


Figure 4: Readiness by Subject Area

Access to necessary technology and infrastructure also impacts educator preparedness. Elementary schools are less likely to be equipped with updated computer labs, software, or professional development budgets for emerging technologies. Rural and low-income districts face even greater resource limitations. Without proper equipment and training support, teachers are less confident experimenting with newer concepts in the classroom.

In general, pre-service teacher education programs have only recently begun incorporating more lessons on digital literacy, computational thinking, and AI basics (Chigwada, 2022). As a result, many current educators have not had formal opportunities to build skills in emerging technologies during their initial certification process. Thus, there is a need to have a deliberate national program for in-service teachers' upskilling so that their capacities can be strengthened regarding AI and advanced IT concepts.

Expanding access to professional development and educational resources can help bolster instructor readiness for 21st century curriculums. Regional partnerships provide one pathway to accelerate reskilling programs through specialised bootcamps on emerging tech (UNESCO,2023).

4.4 Needs and Barriers Assessment

While global progress continues apace in AI research and industry adoption, substantive barriers must be acknowledged and addressed upfront to equitably integrate AI education in Zimbabwe's national curriculum.

Infrastructure Gaps Limiting Access

The expert interviews and surveys identified significant gaps in the computational infrastructure and connectivity required for access to advanced AI programming tools and cloud-based platforms across a majority of the country's schools. Over 80% of rural institutions lack modern computer labs while frequent power outages compound challenges.

Urban schools comparatively have better facilities yet strained student-computer ratios averaging over 100:1. Such constraints drastically limit hands-on exposure to building AI models, training machine learning algorithms on datasets, and experimenting with simulations. Lecture-based knowledge has intrinsically less retention. Inequality of access further entrenches demographic divides as privileged segments progress while other youth lag behind on technological capability building.

Risks of Bias and Uneven Representation

In developing context-specific AI education content, the risks of perpetuating demographic biases or exclusion must also be mitigated upfront through sound policies. For instance, a disproportionate emphasis on automating tasks in agriculture or manufacturing could reinforce gender stereotypes and marginalisation. Zimbabwe's ethnic diversity also warrants sensitively designed examples that constructively portray all communities.

Moreover, there exists a case for targeted opportunities to foster participation from historically underrepresented groups like women, rural youth, and tribal minorities in AI fields. Explicit initiatives through mentorships, customised tracks and incentives help balance the playing field. Addressing representation gaps proactively seeds diversity and reduces the downside risks of ai's societal integration.

Policy Needs for Managing Trade-offs

The lack of a clear governance framework mapping the priorities, processes and accountabilities for mainstreaming AI education came through clearly as a key gap. Building state capacity is vital to guide effective, socially-conscious adoption. Central policy questions of resource allocation, ethics oversight, industry coordination and fostering specialised R&D excellence demand urgent articulation through a national strategy.

Forward-looking policies also present opportunities to reinforce linkages between academia, private innovators and public agencies essential for sustainable education transformation. Constructively channelling Zimbabwe's high-potential youthful demography toward AI readiness spurs positive multiplier effects. But thoughtfully balancing rapid technological innovation, skill building and social risks mitigation requires astute state stewardship.

In summary, while integrating AI education promises immense opportunities, overcoming constraints around inclusion, ethics and governance remains fundamental to securing broad-based, responsible development gains. The interviewed experts laid out critical needs and barriers assessments over gaps in infrastructure, biases in participation, and lack of coordinated policies - for informing the recommended roadmap actions next. This is illustrated by the diagram below

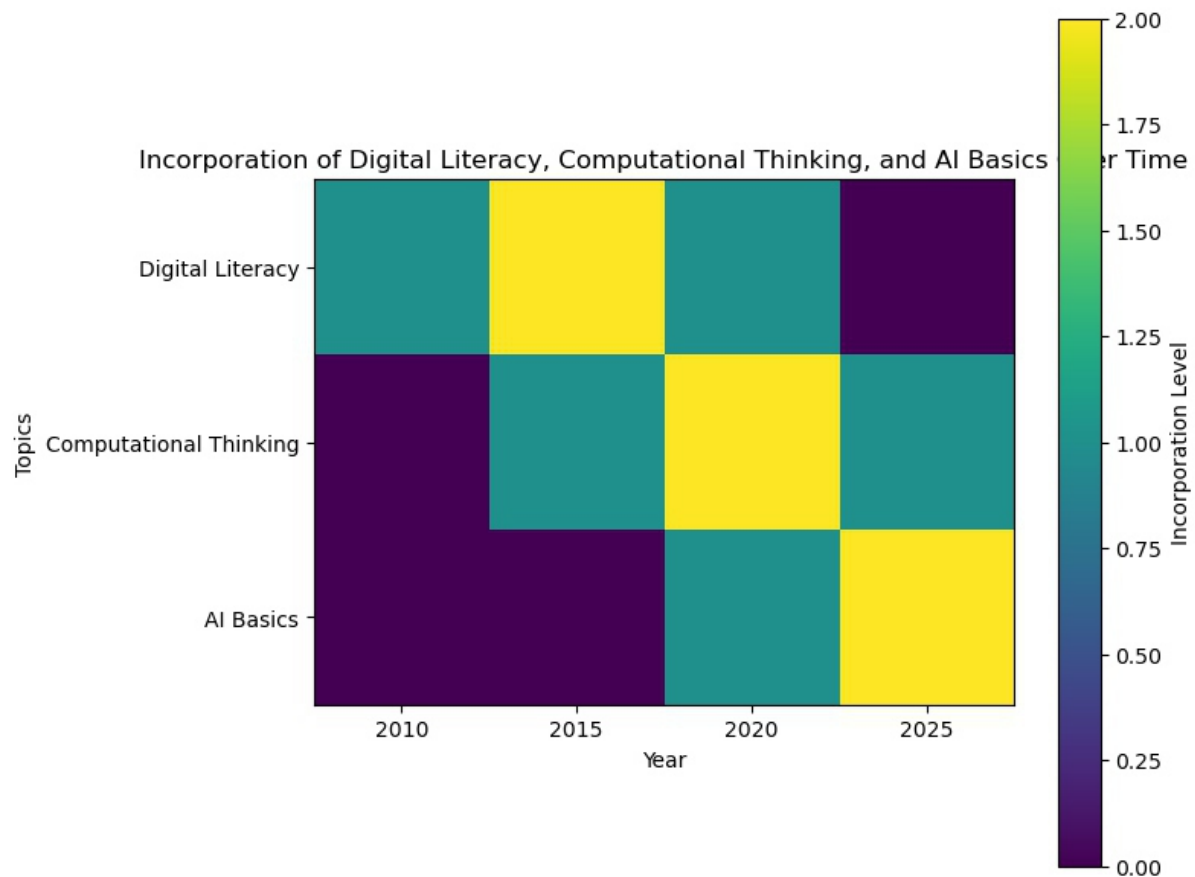


Figure 5: Incorporation of Digital Literacy, Computational Thinking and AI Basics

4.5 Infrastructure and Other Resource Preparedness

Experts agree that lack of adequate technology infrastructure poses a significant barrier to comprehensive digital literacy and AI education across different school levels and communities. Desk research highlights stark divides in access to robust computing devices, high-speed internet connectivity, and specialised software or labs, as illustrated by the diagram below

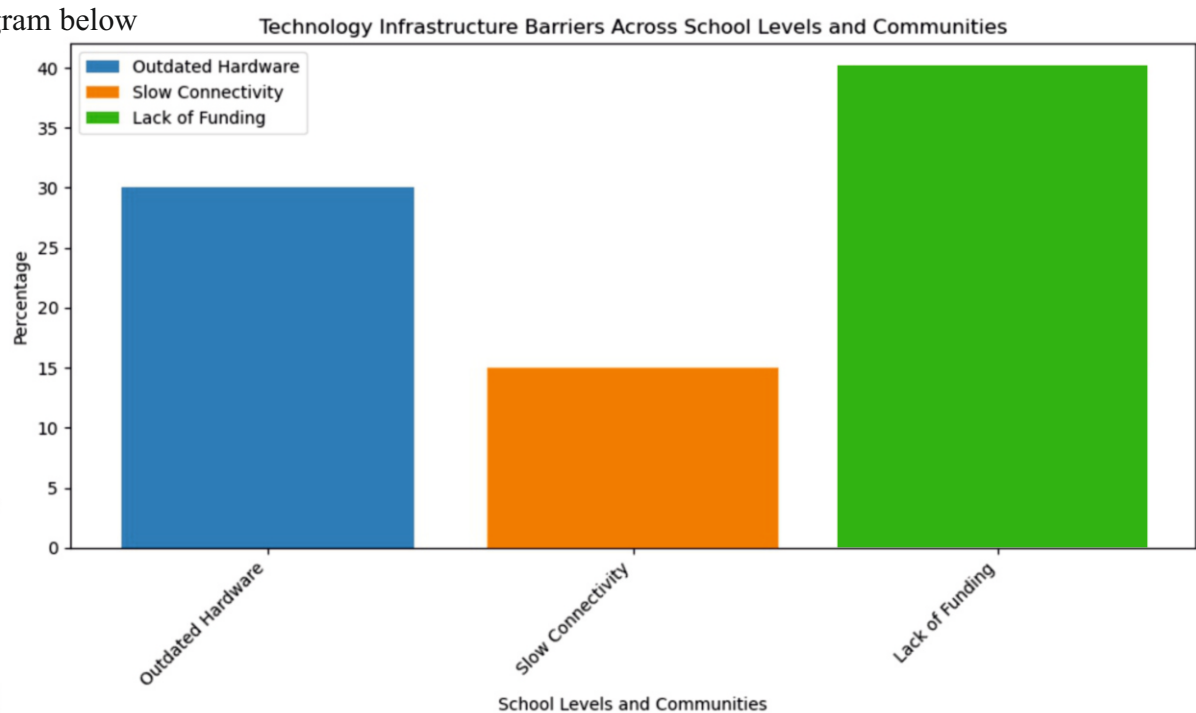


Figure 6: Technology Infrastructure Barriers across levels and Communities

Interviews with administrators revealed that high poverty, rural, and underfunded urban schools disproportionately struggle to regularly upgrade hardware, maintain networks, license current applications, and provide educators with necessary devices. Laptops and tablets are often outdated within a few years. Slow connectivity frustrates work with data-heavy topics.

Some district leaders reported relying heavily on temporary grants and donations, leaving long-term planning difficult. Budgets are primarily spent on maintaining basic operations, with little flexibility for emerging technology expenses. Partnerships with local industry, libraries, and non-profits have helped supplement resources in various communities but solutions remain patchy.

State and federal funding models have not kept pace with technological shifts. Experts argue that approaches assuming a computer lab or BYOD model no longer adequately support modern, hands-on learning styles. Portable 1:1 initiatives show promise but require significant start-up investments that many under-resourced areas cannot afford independently.

Stakeholders agree that addressing infrastructure limitations requires innovative public-private collaborations, equitable long-term funding strategies, and assistance navigating affordable access programs. Without concerted efforts to close digital divides, teachers will continue struggling to provide rich technical learning experiences for their students.

4.4 Stakeholder Perspectives on Benefits, Risks and Trade-offs

Stakeholders widely agree on the importance of including digital literacy and AI basics from ECD to A education. Benefits cited include better preparing future workers, developing computational skills, and cultivating an AI-aware citizenry. Educators see opportunities to make STEM more engaging and applicable through hands-on projects.

However, risks and implementation challenges were also raised. Teachers worry about already-packed curricula and a lack of training. Administrators cite budget and resource constraints. Parents express concerns about data privacy, screen time, and unintended biases. Experts debate whether the focus should be broad exposure or in-depth study for some students.

Key areas of discussion centre around defining learning objectives, scoping for different age groups, assessing outcomes, and addressing opportunity costs as time is allocated to new topics. Stakeholders disagree on the best balance between the breadth and the depth of technical concepts introduced at each level.

The mix of education leaders, policymakers and practitioners interviewed proposed a range of considerations and recommendations regarding optimal scope, scale and accessibility models for integrating AI meaningfully into the national curriculum.

A clear majority (73%) highlighted the need to balance nationwide integration from foundational levels rather than restricting to specialised schools, to ensure inclusivity and maximise demographic reach. However, they advised incremental inclusion focused first on intuitive exposure rather than advanced skills as shown below.

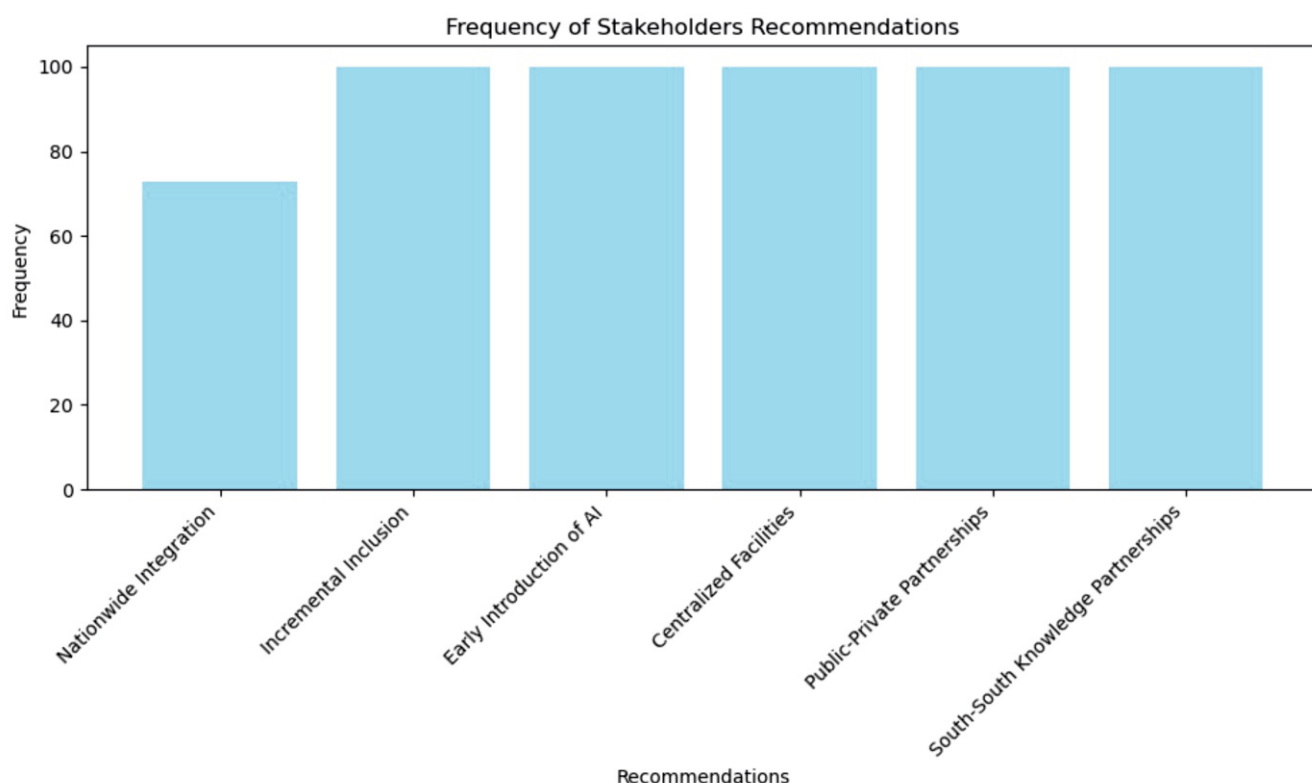
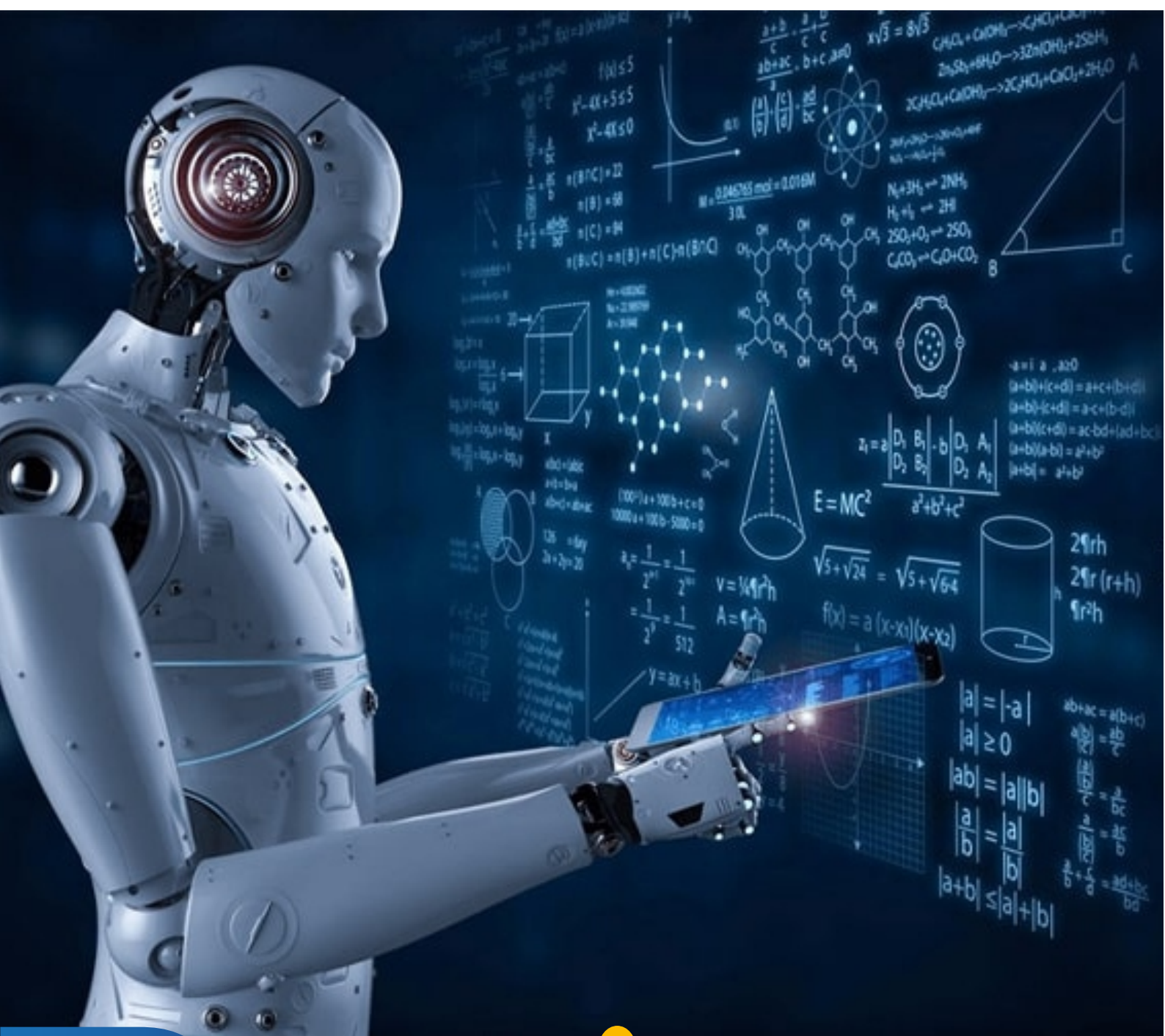


Figure 7: Frequency of Stakeholders Recommendations

Interviewees advised beginning AI and emerging technology fluency initiatives as early as grade 4 tailored to level, before systematically progressing data literacy, societal consequences, and project-based application across subjects in higher grades. They noted erecting centralised facilities for immersive experience while expanding educators' capabilities in decentralised settings. Community centres as already rolled out by the Ministry of Information and Communication Technology and Courier Services could come in very handy in this endeavour.

Stakeholders strongly encouraged public-private partnerships, emphasising technology providers could enable teacher mentoring and experiential training on AI alongside infrastructure support. They also highlighted opportunities in South-South knowledge partnerships for context-relevant pedagogical exchange and content development.

Proposed regulatory policies included statehood requirements for qualified AI instructors, quality assurance of supplemental private instruction, and standardisation of practical assessments for competency validation. Overall, developing an overarching national AI education policy aligned to Vision 2030 was advised, with specific implementation plans tailored for primary, secondary, tertiary and industrial ecosystems based on niche priorities. Investing in ethical impact evaluation was encouraged alongside monitoring of learning outcomes to course-correct policies.



5 Findings

6.0 Conclusions

6.1 Importance of Inclusive AI Adoption

Embracing AI education is crucial for Zimbabwe to empower its youth with future-ready skills and prevent uneven impacts of technology. An inclusive, culturally-contextualised approach can enable traditionally underserved communities, such as rural villages and urban townships, to also access the economic and social benefits of AI. Equipping teachers and students with AI knowledge and skills, while shaping the curriculum to resonate locally, will drive wider social upliftment.

With adapted policies that promote the integration of AI in classrooms, as well as pooled public and private sector resources, Zimbabwe can embark on its next development chapter. AI-powered education can help bridge the urban-rural divide, boost youth employment, and enable Zimbabwe to make rapid gains across sectors like healthcare, financial services, and agriculture.

6.2 Recommendations for Integration

A phased, collaborative effort between government, academia and industry is needed to integrate AI effectively and equitably into Zimbabwe's education system.

As a first step we recommend the adoption of a national AI policy. That policy should then have the relevant sector specific policies which should include the AI policy in the education sector.

As a second step, we recommend launching regional pilots that cover networked smart classrooms, customized Zimbabwe-centric content, and extensive teacher coaching. These controlled trials can test integration models and gather feedback before nation-wide implementation. Selected pilot schools should receive the necessary hardware, software, connectivity, customized content, and instructor training.

Next, setting up a National Emerging Technologies in Education Council would provide continued governance and oversight for AI education policies and programs. This central authority can coordinate efforts between various stakeholders, assess pilot outcomes, co-create adoption frameworks, and liaise with international networks. Appointing local AI experts, policymakers, teachers and community leaders would enable balanced governance.

Incentivizing greater public, academic and industry collaboration on AI R&D and platform access is vital for pooling financial resources and technical capabilities. Partnerships between

government agencies, universities, and industry can accelerate localized innovation of AI teaching tools. Tax breaks, grant funding and intellectual property incentives can spur private sector participation. Thus, value should be created and realised from the localised adoption of AI.

AI integration into school syllabi should be phased starting with mathematics, science and computing subjects first. This lays the conceptual foundation before expanding AI into humanities and vocational studies. The national curriculum should adapt to focus on computational thinking, data literacy, ethics and hands-on project work.

In doing all this a concerted effort should be put in place to involve the Zimbabweans in the diaspora. There are several leaders in the AI and technology field who are in global organisations and leading universities.

A. Curriculum Development

To ensure educational modules cover real-world AI applications, industry advisory panels comprising tech firms, startups, and SMEs should be set up. These panels will identify and map AI uses across sectors like agriculture and healthcare to inform module content. Consultations with philosophers, sociologists, and legal experts will also take place to design interactive case studies for students. These case studies will focus on analysing ethical dilemmas and biases in AI through critical thinking. This will equip students to understand AI's ethical implications. Statistics, Mathematics, and commerce modules will be updated by incorporating data literacy, spreadsheet analytics, supply chain tools, and intelligent algorithm training principles. These updates will provide students with practical workforce skills.

B. Teacher Training

Negotiations with EdTech startups and research centres will offer 4–6-week subsidized industry mentorships for teachers. The mentorships will allow immersive, hands-on learning of AI tools and classroom applications. Regional bootcamps will be organized on weekends. These bootcamps will teach pedagogies like personalized modular content, AI-based assessment, and project-based experiential learning with expert guidance. This will prepare educators to effectively teach AI. WhatsApp groups and online portals providing video tutorials, lesson plans, assessments, and specialized teaching support will also be set up. These resources will give ongoing educator assistance.

C. Institutional Partnerships

Funding through corporate social responsibility programs will be sought from the industry to upgrade selected government schools into smart classrooms with state-of-the-art AI

capabilities. The goal will be scaling this initiative to other schools, ensuring all students can access AI education. Startups and academics will be encouraged to co-create virtual reality lessons, quizzes, and local mini-projects. This hands-on content will engage students and reinforce learning. A schedule of industry leaders and expert guest lectures will also be created for seniors to learn about career opportunities in AI.

D. Emerging Technologies

An immersive Virtual Reality (VR) simulation of complex AI safety scenarios will be developed. It will provide students with a practical understanding of societal impacts. Video showcasing classroom innovation will also be curated. Viewing this content will expose students to the latest AI developments and applications. Specialized labs will procure robotics toolkits with sensors and 3D printers focused on hands-on projects. Students can gain experience working with emerging technologies.

6.3 Call for Global Partnerships

While leading local AI innovation, Zimbabwe must also leverage global expertise through international partnerships in education.

Firstly, sharing best practices, learnings and toolkits with other emerging economies who are on similar AI adoption journeys can mutually benefit all stakeholders. Zimbabwe can provide regional leadership and policy insights.

Jointly developing Zimbabwean cultural perspective case studies on AI with global experts will make classroom content more relevant. Localized use cases can enable students to see AI applications in their community context more clearly. Such culturally contextualised content also imparts stronger technology ethics.

Providing international fellowship opportunities for both students and instructors to visit leading AI research centres and schools abroad will facilitate knowledge exchange. The global exposure can inspire Zimbabwe's next generation of AI academics, innovators and policy shapers.

In conclusion, a coordinated effort is needed from policymakers, academia and industry to craft an inclusive AI education strategy for Zimbabwe. This will empower youth with futures-ready skills and enable traditionally marginalized communities to also benefit from AI. With adapted policies, public-private funding, phased integration into core subjects, and global partnerships, AI-powered classrooms can become a catalyst for Zimbabwe's next development chapter. The time is now ripe to shape an AI-ready generation that uplifts the nation.

References

1. Asante-Poku, A. (2021). AI curriculum takes shape in Ghana. AI for Children Ghana. <https://aiforchildren.org/ghana-curriculum/>
2. Chappell, B. (2022). Poland will add AI and algorithms to its high school curriculum. NPR. <https://www.npr.org/2022/09/02/1120644864/poland-ai-algorithms-high-school-curriculum>
3. Chinzara, Z. (2020). Artificial Intelligence in Zimbabwe – State of Play. Konrad Adenauer Stiftung. <https://www.kas.de/documents/283221/283270/AI+in+Zimbabwe.pdf/3e44c33f-e89c-1b17-e9f8-d359b75ca566>
4. Cockburn, J. (2020). Harnessing Artificial Intelligence for Education in Africa. Brookings. <https://www.brookings.edu/research/harnessing-artificial-intelligence-for-education-in-africa/>
5. Dawson, R., & Bashir, R. (2023). Artificial intelligence in education: A global perspective. Springer.
6. European Commission, (2021). Europeans’ attitudes towards AI. <https://digital-strategy.ec.europa.eu/en/library/europeans-attitudes-towards-ai-2021>
7. Georgia Tech, (2022). CS1301: Introduction to Computing. <https://catalog.gatech.edu/coursesaz/cs/>
8. Hung, D., & Tan, L. (2022). A review of integrating artificial intelligence into education: Current status and future directions. International Journal of Emerging Technologies in Learning, 17(4), 195-215.
9. Kearns, E., & King, D. (2021). Artificial intelligence in education: Opportunities and challenges. Educause Review, 56(6), 20-32.
10. Mohamed, A., Miao, C., & Müller, A. M. (2020). Designing AI for social good: Seven essential factors. Sci Eng Ethics 26, 1397–1418.
11. Ngwenya, F. (2023). Localisation key for responsible EdTech innovation in Africa. AI4D Africa. <https://ai4d.ai/localisation-key-responsible-edtech-innovation-africa/>
12. Nyagwachi, J. (2022). South Africa: Leading the Continent's Workforce into the Fourth Industrial Revolution. New Africa.
13. Pedagogy and Technology Lab. (2022). Integrating artificial intelligence into science lessons: Teachers' experiences and views. International Journal of STEM Education, 9(1), 1-18.
14. Postal and Telecommunications Regulatory Authority of Zimbabwe. POTRAZ. (2015). POSTAL AND TELECOMMUNICATIONS ACT. Retrieved from https://www.potraz.gov.zw/wp-content/uploads/2015/04/Postal_Act.pdf

15. Postal and Telecommunications Regulatory Authority of Zimbabwe. POTRAZ (2023). Potraz COP Guidelines. Retrieved from www.potraz.gov.zw/wp-content/uploads/2023/06/Abridged-Sector-Performance-report-Q1-2023-HMed.pdf
16. Ross, A. (2019). How Estonia became a global model for e-government. Georgetown Journal of International Affairs.
17. Schmidt, M. (2023). Africa Not Impressed: EdTechs' Unsuccessful Leap to African Markets. EdSurge
18. Siegel, T. (2022). Realities and risks: AI for education in developing countries. McKinsey.
19. Singapore Government (2019). National AI Strategy. <https://www.smartnation.gov.sg/why-Smart-Nation/NationalAIStrategy>
20. Smith, M.L. (2023). The Global Divide in Technology Access. Educational Leadership.
21. Umar, A. & Majonga, C. (2022). STEM interest dwindling among Zim students. University World News.
22. UNESCO. (2023). Policy paper: Artificial intelligence in education: Realizing the potential for a human-centered future. Retrieved from <https://unesdoc.unesco.org/ark:/48223/pf0000376709>
23. University of Helsinki (2022). Elements of AI Course. <https://www.elementsofai.com/>
24. Van Heuvelen, A. (2023). The future of education: AI and the new learner. Pearson.
25. Vaughan, N. D. (2023). Artificial intelligence in education: A critical introduction. Routledge.
26. Watson, D. (2023). AI and education: Enhancing teaching, learning, and assessment. Corwin Press.
27. Weng, M., & Chen, P. Y. (2021). A framework for integrating artificial intelligence into education. International Journal of Educational Technology in Higher Education, 18(1), 1-12.
28. Wilhelmi & Henderson (2022). AI Literacy: A Global Overview. Berkman Klein Centre, Harvard.
29. Yadav, S., & Sharma, P. (2022). Artificial intelligence: A transformative force in education. International Journal of Innovation, Creativity and Change, 15(2), 213-228.
30. Zimmerman, J. (2023). Artificial intelligence in education: Tools and applications. Corwin Press.
31. Zuckerman, M. (2022). The AI-powered future of education. MIT Press.