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FROM INFORMATION GATEKEEPERS TO AI LEARNING PARTNERS: REIMAGINING ACADEMIC LIBRARIES FOR INCLUSIVE AND SUSTAINABLE STEM EDUCATION IN THE GLOBAL SOUTH

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Abstract

Purpose: *The purpose of this paper is to examine the changing role of academic libraries from traditional information gatekeepers to AI learning partners in promoting inclusive and sustainable Science, Technology, Engineering and Mathematics education in the Global South.*

Design/Methodology/Approach: *The paper adopts a conceptual and narrative review approach. It draws on contemporary literature and emerging global practices to examine the integration of Artificial Intelligence technologies into academic library services. The review focuses on AI powered discovery systems, chatbots, adaptive information services, predictive analytics, virtual research support, and digitally inclusive library practices within higher education.*

Findings: *The paper reveals that AI enabled academic libraries have strong potential to improve equitable access to STEM knowledge, support personalised learning, strengthen research innovation, and reduce educational inequalities among students in the Global South. It further shows that AI driven library services can support learners with diverse needs, including students with disabilities, by improving information accessibility, user engagement, and learning support. However, the paper also identifies major challenges affecting AI adoption in academic libraries, including algorithmic bias, digital exclusion, inadequate technological infrastructure, ethical concerns, limited funding, and the need for new professional competencies among librarians.*

Implication: *The paper implies that academic libraries in the Global South must move beyond conventional information provision and become active partners in digital learning, research support, and inclusive STEM education. This requires investment in AI infrastructure, librarian capacity building, ethical AI governance, and policies that promote digital inclusion.*

Originality/Value: *The paper contributes to the discourse on the future of academic libraries by positioning them as strategic AI learning partners for inclusive and sustainable STEM education. It provides a conceptual basis for rethinking library services in ways that support educational equity, research excellence, and sustainable development in the Global South.*

Keywords: *Artificial Intelligence; Academic Libraries; Global South; Inclusive Education; STEM Education; Sustainable Education; AI Learning Partners.*

Paper type: Conceptual/Narrative review.

Introduction

Higher education is being reshaped by digital transformation, open knowledge systems and the rapid diffusion of artificial intelligence across teaching, learning, research and institutional management. Within this transformation, STEM education occupies a strategic position because scientific and technological capacity supports industrial development, climate resilience, public health, food security, infrastructure, energy transition and national innovation. The UNESCO Science Report stresses that countries seeking smarter development require stronger

scientific capacity, improved research systems and wider participation in knowledge production (UNESCO, 2021a). Yet, many institutions in the Global South continue to face unequal access to digital infrastructure, scholarly resources, laboratory facilities, reliable connectivity and advanced learning support. These inequalities determine who can participate in STEM, who can publish, who can access evidence and who can contribute to development solutions.

Academic libraries have historically organised, preserved and mediated scholarly knowledge. Their traditional identity as information gatekeepers emerged from a model in which librarians selected collections, controlled access to catalogues, guided users through reference services and protected the integrity of scholarly resources. That role remains important, but it is no longer sufficient. Contemporary academic libraries operate in a networked knowledge economy where students and researchers expect immediate access to full-text resources, research data, multimedia learning objects, open educational resources, software tools and personalised support. Cox et. al. (2019) argue that AI is likely to alter academic library work by changing discovery, collection management, user support and professional identity. The library is therefore becoming not only a repository but also a learning partner, research partner and inclusion partner.

This repositioning is urgent in STEM education since STEM students and researchers need access to databases, simulations, standards, protocols, laboratory manuals, code repositories, patent information, geospatial data, open datasets, specialised journals and research integrity guidance. They also require support in information literacy, data literacy, evidence appraisal and responsible use of emerging technologies. The Association of College and Research Libraries (2017) links academic libraries to student learning and success when instruction, research support and engagement are embedded into the learning experience. Scoulas and De Groote (2022) also show that undergraduate library use can influence learning outcomes beyond grade point average. These findings support the view of the library as an educational actor rather than an auxiliary service unit.

Artificial intelligence intensifies this shift through machine learning, natural language processing, recommender systems, conversational agents, predictive analytics, automated feedback, intelligent tutoring systems and generative AI tools (Chen, Chen, & Lin, 2020; Ouyang & Jiao, 2021; Zawacki Richter et al., 2019). In academic libraries, such technologies can improve resource

discovery, automate metadata enrichment, provide round-the-clock virtual reference, support research data management, generate accessible formats, detect patterns in user needs and help learners navigate complex STEM information environments (Concha, Palacios Zenteno, & Tello Alfaro, 2024; Hervieux & Wheatley, 2021). The opportunity is pedagogical, social and developmental because AI-enabled libraries can widen participation in STEM where classrooms, laboratories and research support systems remain constrained.

The Global South context gives this argument a distinct urgency just as the International Telecommunication Union (2023) reports a substantial internet use gap between high income and low-income countries, while the World Bank (2024) describes the digital divide as a development divide. AI-driven library innovations cannot therefore be imported without analytical scrutiny from high income contexts. They must be adapted to affordability, local infrastructure, data sovereignty, language diversity, disability inclusion, gender inclusion and long-term sustainability. Thus, this paper examines how academic libraries can move from information gatekeepers to AI-learning partners that support inclusive and sustainable STEM education in the Global South.

Statement of the Problem

Despite the expansion of digital higher education, access to quality STEM knowledge remains uneven. Many universities in the Global South operate with limited subscriptions to high impact journals, weak broadband, inadequate electricity, insufficient laboratory equipment and limited staff capacity for advanced digital services. The STEM students from rural communities, low-income households, linguistic minorities, women and learners with disabilities are often further disadvantaged by device costs, inaccessible platforms, weak digital skills and lack of personalised academic support. The UNESCO (2023a) warns that technology in education can reproduce inequality when access, governance and pedagogical purpose are poorly defined. This warning applies strongly to AI-enabled library services because poorly designed tools can turn innovation into another form of exclusion.

The problem is not only the availability of AI technologies but also the limited institutional capacity to integrate them responsibly into academic library practice. Many libraries in developing countries remain underfunded and are treated as support departments rather than strategic partners in learning and research. Where AI tools are introduced, they are often fragmented, donor dependent, vendor driven or disconnected from curriculum needs.

Librarians may also lack training in AI literacy, data ethics, algorithmic accountability, prompt engineering, digital accessibility and research analytics. At the same time, institutional policies on data privacy, accessibility, procurement and AI governance are often weak. These conditions create a gap between the transformative promise of AI and the real conditions under which libraries serve STEM learners.

The scholarly gap is also significant because existing studies have examined AI in higher education, AI in libraries, inclusive education and STEM development, but fewer studies integrate these strands around academic libraries as AI learning partners for inclusive and sustainable STEM education in the Global South. The literature, therefore, requires a synthesis that connects academic library transformation, STEM learning, digital inclusion, assistive technologies, responsible AI and sustainable development. This paper responds to that need by presenting a narrative review and a strategic argument for reimagining academic libraries as active partners in STEM education.

Objectives of the Study

The broad objective of the study is to examine how AI-enabled academic libraries can transform STEM education in the Global South by promoting inclusive, equitable, and sustainable learning, while identifying opportunities, challenges, and strategic pathways for effective implementation. The specific objectives are to:

1. examine the evolving role of academic libraries in sustainable STEM education.
2. explore AI powered technologies transforming library services in higher education.
3. analyse how AI enabled libraries can promote inclusive STEM learning.
4. ascertain the challenges confronting AI integration in academic libraries in the Global South.
5. propose strategic pathways for repositioning academic libraries as AI learning partners.

Research Questions

The research questions that guide this study are as follows:

1. How are academic libraries evolving in response to AI driven educational transformation?
2. What AI technologies are shaping contemporary library services in STEM education?
3. In what ways can AI-enabled libraries foster inclusive and sustainable STEM education?
4. What barriers hinder effective AI integration in academic libraries in the Global South?

5. What strategies can enhance the future readiness of academic libraries?

Table 1: Alignment of objectives, research questions and analytical focus

Objective	Research question	Analytical focus
Examine the evolving role of libraries in sustainable STEM education	Research Question 1	Transformation of library roles, learning support and research support
Explore AI powered library technologies	Research Question 2	Discovery systems, chatbots, recommender systems, analytics and virtual support
Analyse inclusive STEM learning contributions	Research Question 3	Equity, accessibility, Universal Design for Learning, assistive technologies and gender inclusion
Investigate barriers in the Global South	Research Question 4	Infrastructure, funding, ethics, skills, policy and institutional readiness
Propose strategic pathways	Research Question 5	Capacity building, digital infrastructure, partnerships and responsible AI governance

Conceptual and Theoretical Review

Artificial Intelligence in Education

Artificial intelligence (AI) in education refers to computational systems that perform tasks associated with reasoning, pattern recognition, language processing, decision support and adaptive response. In educational contexts, AI includes intelligent tutoring systems, automated assessment, learning analytics, adaptive platforms, recommender systems, chatbots, natural language processing tools and generative AI applications (Chen et al., 2020; Crompton & Burke, 2023). Luckin et. al. (2016) describe AI as a means of supporting teaching and learning through systems that model learner progress and adapt educational support. Zawacki Richter et al. (2019) found that early AI research in higher education concentrated on profiling, prediction, assessment and adaptive systems, while later studies have moved towards human centred, ethical and pedagogically accountable AI use.

Ouyang and Jiao (2021) identify three paradigms of AI in education including AI directed learning, AI supported learning and AI empowered learning. Academic libraries are especially aligned with AI-supported and AI-empowered learning because their core functions involve mediation, curation, access provision, information literacy and collaborative knowledge creation. The AI, therefore, does not replace librarians but reshapes their knowledge work by strengthening their capacity to provide timely,

personalised and context sensitive academic support.

Academic Libraries in the Digital Knowledge Economy

The digital knowledge economy has changed the operating logic of academic libraries. Traditional services were organised around acquisition, cataloguing, circulation, reference assistance and physical access. These functions remain valuable, but the digital university now requires capacities in digital scholarship, open access publishing, research data management, information literacy, copyright literacy, bibliometrics, digital preservation, knowledge equity and platform navigation. Academic libraries increasingly operate as hybrid environments where physical spaces, digital repositories, cloud services, electronic resources, makerspaces and online learning platforms intersect.

The AI can strengthen this role by improving search, recommendation, robotic process automation, analytics and service personalisation. Hervieux and Wheatley (2021) show that academic librarians perceive AI as both an opportunity and a challenge, particularly in relation to professional identity, skills and ethics. Concha et al. (2024) confirm that AI applications in libraries include chatbots, metadata support, recommendation systems, information retrieval, collection management and user services. These developments require librarians to move beyond resource custodianship towards roles as data stewards, AI mediators, digital inclusion advocates and learning designers.

Academic libraries are also strategic sites for open knowledge just as UNESCO (2021b) frames open science as a route to reducing knowledge and technology divides by making scientific knowledge more accessible, reusable and inclusive. Libraries can operationalise this in STEM education by helping learners access open datasets, open educational resources, preprints, repositories, standards and research tools. Thus, AI can enhance this role when it improves discoverability, language accessibility, content adaptation and research navigation.

STEM Education, Inclusion and Sustainable Development

STEM education refers to the integrated development of knowledge, skills and dispositions in science, technology, engineering and mathematics. It supports problem solving, experimentation, quantitative reasoning, innovation, design thinking and evidence-based decision making. The National Academies of Sciences, Engineering, and Medicine (2018) emphasise that undergraduate STEM education should be assessed through access, learning, persistence,

completion and workforce preparation. In the Global South, these concerns are linked to national development because STEM capacity influences health systems, agriculture, climate adaptation, manufacturing, digital services and energy transition.

Inclusive education is concerned with removing barriers that prevent learners from participating fully in educational life. In the digital era, inclusion includes affordable connectivity, accessible platforms, assistive technologies, culturally relevant content, language support, flexible pathways and recognition of diverse learner needs. CAST (2024) defines Universal Design for Learning as a framework that supports multiple means of engagement, representation, action and expression. AI enabled libraries can contribute to inclusion through screen reader friendly databases, optical character recognition, captioning, audio formats, structured navigation, low bandwidth access, mobile friendly repositories and multilingual guidance. WHO and UNICEF (2022) emphasise that assistive technology is essential for participation, independence and dignity.

AI-Powered Library Technologies

AI-powered library technologies include intelligent discovery systems, chatbots, recommender systems, predictive analytics, automated indexing, generative AI assistants and assistive AI tools. Their value in STEM education depends on how they connect learners with reliable resources, guide research processes, support accessible formats and improve service planning. Predictive analytics can help libraries anticipate demand and identify underserved groups, but such analytics must be governed carefully because learning behaviour data can expose sensitive information. Generative AI can assist with search strategies, plain language summaries, translation and research planning, but Miao and Holmes (2023) caution that generative AI in education requires safety, equity, intellectual property protection, transparency and human oversight.

Table 2: AI powered library technologies and STEM education functions

AI technology	Library application	STEM education contribution	Inclusion benefit
Intelligent discovery systems	Semantic search, resource recommendation and database navigation	Improves access to journals, datasets, protocols and technical literature	Supports users who do not know specialist vocabulary
AI chatbots and virtual assistants	Round the clock reference service and orientation	Helps students locate STEM resources outside	Assists distance learners and users with limited

	support	library hours	mobility
Recommender systems	Personalised reading lists and open resource suggestions	Connects learners with level appropriate STEM content	Reduces cognitive load and improves relevance
Predictive analytics	Demand forecasting and service planning	Improves collection alignment with curriculum and research needs	Identifies underserved groups and service gaps
Generative AI assistants	Search strategy support, summarisation and translation	Supports literature review, coding support and concept clarification	Provides adaptive explanations and accessible formats
Assistive AI tools	Speech to text, text to speech, captions, OCR and screen reader support	Enables participation in STEM learning and research	Supports learners with disabilities and diverse learning needs

Theoretical Framework

This paper adopts a combined theoretical framework built on the Technology Acceptance Model, Diffusion of Innovation Theory, Connectivism and Sociotechnical Systems Theory. The Technology Acceptance Model is useful because AI-enabled library services will not succeed merely because they are available. Students and librarians must perceive them as useful, easy to use, trustworthy and aligned with academic needs. In the Global South, perceived usefulness may be shaped by cost, language, reliability and relevance to local STEM problems, while perceived ease of use may be influenced by digital literacy, device quality and accessibility.

Diffusion of Innovation Theory explains why AI library technologies spread unevenly across institutions. Early adopters may implement chatbots, discovery layers and analytics platforms, while late adopters may struggle with funding, policy approval or resistance. Adoption depends on relative advantage, compatibility, complexity, trialability and observability. Connectivism is relevant because learning in the digital age occurs across networks of people, tools, platforms and knowledge resources. The STEM learners engage databases, simulations, repositories, online communities, coding platforms, open data and AI mediated search. Sociotechnical Systems Theory complements this by showing that technology adoption depends on the interaction between technical systems, institutional structures, professional

roles, user behaviour and social values. AI enabled academic libraries therefore require software, governance, training, infrastructure, ethics and inclusive organisational culture.

Methodological Approach

The paper adopted a narrative review design with structured search logic. A narrative review was appropriate because the purpose was not to calculate pooled effect sizes but to integrate conceptual, empirical and policy literature on AI, academic libraries, STEM education, inclusion and sustainable development. Snyder (2019) notes that literature reviews are valuable for mapping knowledge, identifying patterns, clarifying conceptual relationships and developing future research directions. The review followed the broad logic of transparent evidence synthesis while retaining the interpretive flexibility needed to connect multiple fields.

The review drew on peer reviewed journal articles, systematic reviews, policy reports, professional library reports and official institutional documents. Relevant literature was identified through scholarly databases and publisher platforms, including Google Scholar, Scopus indexed journals, Web of Science indexed journals, ScienceDirect, SpringerOpen, IEEE Access, Taylor and Francis, Emerald, College and Research Libraries and repositories of UNESCO, ITU, WHO, UNICEF, OECD, NIST and the World Bank. Search terms included "artificial intelligence in academic libraries", "AI in higher education", "STEM education Global South", "inclusive education", "assistive technology", "Universal Design for Learning", "academic library impact", "open science", "digital divide", "AI ethics" and "generative AI in education."

Sources were included if they were published mainly between 2016 and 2026, addressed AI in education, AI in libraries, STEM education, inclusive education, digital inclusion, academic libraries, open science, assistive technology or responsible AI governance, and were traceable through a DOI, official publisher page or institutional repository. Sources were excluded if they lacked educational or library relevance, were promotional vendor materials, were outside the scope of higher education or offered unverifiable claims without methodological or institutional support. The data were analysed through thematic and conceptual synthesis. Evidence was grouped into themes aligned with the research questions including, library transformation, AI powered technologies, inclusive STEM learning, Global South barriers and strategic readiness. The themes were then interpreted using the theoretical framework.

Thematic Synthesis and Discussion

Transformation from Information Gatekeepers to Learning Partners

The literature reveals a shift from collection-centred libraries to learner and research-centred digital ecosystems. A gatekeeping model assumes that the library controls access to scarce resources and that users come to obtain information. A learning partner model assumes that knowledge is abundant but unevenly accessible, difficult to evaluate and mediated by complex digital systems. Under this model, the library supports learners in finding, interpreting, creating and ethically using knowledge. This is especially relevant to STEM education, where students must work with specialised databases, technical vocabulary, experimental data, research software and rapidly changing evidence.

Artificial intelligence strengthens this learning partner role when it is aligned with human expertise. A chatbot may answer routine questions, but a librarian interprets the deeper learning problem. An AI recommender may suggest resources, but a subject librarian helps students judge relevance and quality. A generative AI tool may produce a summary, but information literacy instruction helps students verify claims, understand limitations and cite responsibly. Cox et al. (2019) and Hervieux and Wheatley (2021), therefore, suggest that AI shifts library work towards higher order mediation, ethics and service design. Academic libraries need to invest in librarians as AI literate educators rather than mere operators of digital systems.

AI Technologies Shaping STEM Library Services

The review identifies intelligent discovery systems, AI chatbots, recommender systems, predictive analytics, automated metadata systems, assistive AI and generative AI tools as the main technologies shaping library services in STEM education. Their value lies in improving access to specialised information, supporting research discovery, reducing cognitive load and enabling personalised guidance. For example, a student searching for climate modelling may be guided towards introductory tutorials, open datasets, statistical software guides, peer reviewed articles and research ethics resources. These supplement teaching by making relevant knowledge easier to locate and use.

However, AI personalisation must be carefully designed such that if recommendation algorithms are based only on popularity, they may privilege dominant knowledge traditions and overlook local research, African journals, Indigenous knowledge and non-Western contexts. If systems rely heavily on user data, they may create privacy risks. If interfaces are complex, they may exclude students with low

digital literacy. Responsible personalisation therefore requires transparency, user control, accessibility and human oversight. UNESCO (2021c) and NIST (2023) stress that AI systems should be accountable, trustworthy and risk aware, and these principles should guide library procurement and implementation.

AI-Enabled Libraries, Inclusion and Sustainable STEM Education

AI-enabled libraries can foster inclusive STEM education by reducing barriers to knowledge access. Many students in Global South universities enter STEM programmes with uneven preparation, limited access to textbooks, weak internet access and low familiarity with scholarly databases. Thus, AI-supported discovery tools, adaptive guides and virtual reference systems can reduce the intimidation associated with technical information seeking and provide support beyond normal library hours. This is important for working students, distance learners and students who share devices or internet access.

Moreover, accessibility must be treated as a design principle rather than an afterthought. Universal Design for Learning encourages multiple ways of accessing, engaging with and expressing knowledge (CAST, 2024). In library practice, this implies databases that work with screen readers, videos with captions, interfaces with adjustable contrast, mobile friendly repositories, plain language guides, multilingual support and flexible formats. The AI can assist by generating captions, summaries, translations and alternative text, but these outputs require human review for accuracy and cultural appropriateness. Inclusion therefore depends on the partnership between intelligent systems and trained library professionals.

Learners with disabilities often face compounded barriers in STEM education because laboratory manuals may be inaccessible, diagrams may lack descriptions, mathematical notation may not work well with screen readers and specialised software may not meet accessibility standards. Thus, AI-enhanced assistive technologies can help address these problems through optical character recognition, text to speech, speech to text, image description, captioning, adaptive interfaces and intelligent navigation. Potnis and Mallary (2021) show that academic libraries must address service divides affecting disabled patrons, including technology access, staff support and institutional responsiveness.

Digital inclusion is a precondition for AI-enabled libraries since ITU (2023) reports that 93 percent of people in high-income countries used the internet in 2023 compared with 27 percent in low-income countries. This gap affects library access because AI services depend on connectivity, devices, electricity,

cloud platforms and digital literacy. Bridging the divide requires institutional investment in libraries as digital infrastructure, national policies that connect library development to broadband and open science, regional consortia for shared access and design choices that prioritise low bandwidth platforms, offline resource packages, open-source software and mobile first access.

Barriers Hindering AI Integration in the Global South

The review confirms that infrastructure, funding, skills, ethics, policy and digital exclusion are the main constraints on AI integration in Global South academic libraries. These barriers are mutually reinforcing because weak funding limits infrastructure, weak infrastructure reduces service reliability, limited staff training reduces adoption, weak policy increases ethical risk and digital exclusion prevents users from benefiting even when systems are available. A chatbot that fails during network outages may damage user trust, while a discovery platform that requires high bandwidth may exclude students using low-cost mobile data. Infrastructural constraints also include fragmented library management systems and poor metadata quality. Many institutions use legacy catalogues that do not integrate easily with modern discovery layers, repositories, analytics tools or accessibility plugins. Data quality problems, including inconsistent metadata and incomplete cataloguing, reduce the effectiveness of AI search and recommendation systems. Foundational investment is therefore needed in metadata quality, interoperability, cybersecurity and digital preservation because AI cannot compensate for weak information architecture.

Ethical and privacy concerns are especially important because library users traditionally expect confidentiality in their reading, searching and research behaviour. The AI systems may collect, analyse or infer information about user interests, academic weaknesses, disabilities or sensitive research topics. Without clear governance, such data can be misused or exposed. Algorithmic bias is another concern because AI tools trained on data from high income contexts may underrepresent African scholarship, local journals, minority languages and Global South research priorities. Therefore, OECD (2019), UNESCO (2021c) and NIST (2023) emphasise human centred and risk aware AI, and that libraries should translate these principles into procurement standards, transparency notices, bias audits and user education.

Table 3: Challenges of AI integration and mitigation options

Challenge	Manifestation in Global South academic libraries	Strategic mitigation
Weak infrastructure	Unstable power, poor broadband, limited devices and low server capacity	Invest in resilient connectivity, low bandwidth platforms, shared infrastructure and offline access options
Funding limitations	Inability to sustain subscriptions, devices and maintenance	Use consortia, open source tools, phased implementation and targeted donor partnerships
Skills gaps	Limited AI literacy, data skills and accessibility expertise among staff	Provide continuous professional development and embed AI modules in LIS curricula
Ethical risks	Privacy exposure, algorithmic bias and opaque vendor systems	Adopt AI governance, privacy impact assessment, bias audits and human oversight
Policy weakness	Absence of institutional AI, accessibility and open science policies	Create university wide policies that recognise libraries as strategic digital learning partners
Digital exclusion	Rural, low income and disabled learners unable to use AI services effectively	Prioritise UDL, assistive technologies, mobile access, language support and user co design

Strategic Pathways for Future Readiness

Sustained capacity building is critical for academic librarians to effectively manage AI-enabled services. Librarians require structured professional development in AI concepts, prompt engineering, database automation, metadata enrichment, data privacy, digital accessibility, research analytics, and the responsible use of generative AI (Ayinde, 2026; Bond et al., 2024). Training should be practical and linked to library service redesign. For example, workshops on generative AI should not only explain the mechanics of chatbots but also demonstrate how librarians can support students in developing search strategies, verifying sources, detecting fabricated citations, and applying AI ethically. Extending AI literacy to students and faculty through library instruction programs further enhances institutional capacity and ensures broad engagement in digital learning (Cox, Pinfield & Rutter, 2019; Hervieux & Wheatley, 2021).

Strategic investment in digital infrastructure is also vital for positioning libraries as core components of the digital campus. Essential infrastructure includes reliable broadband, electricity backup, accessible computer

workstations, institutional repositories, discovery systems, authentication tools, cybersecurity, assistive technologies, and digital preservation systems (ITU, 2023; World Bank, 2024). Investment should be phased, beginning with high-value, manageable interventions such as accessible research guides, open-source chatbots, repository enhancements, digital literacy modules, and mobile-friendly discovery platforms, before scaling to complex predictive analytics or advanced generative AI systems (Concha, Palacios Zenteno & Tello Alfaro, 2024; Xu & Ouyang, 2022).

Collaborative partnerships strengthen the relevance and effectiveness of AI-enabled STEM libraries. Librarians, STEM faculty, disability support units, IT departments, students, government agencies, technology firms, and civil society organizations can coordinate to align library services with academic priorities. Faculty identify curriculum needs, librarians translate these into information services, IT units provide infrastructure support, and disability support units guide accessibility design. Such partnerships can generate shared programs including AI literacy clinics, data analysis boot camps, inclusive STEM resource hubs, open science workshops, research data management services, and assistive technology laboratories (Mudaly, 2023; CAST, 2024).

Ethical and inclusive AI governance ensures that library services remain responsible, equitable, and trustworthy. All AI initiatives should be guided by clear policies on privacy, consent, transparency, accessibility, data retention, bias mitigation, academic integrity, and human oversight. Users must understand when they interact with AI, what data are collected, how long data are retained, and the review process for automated decisions. Recommendation and analytics systems should be regularly audited for potential biases against marginalized groups. Incorporating feedback from students with disabilities, women in STEM, rural learners, and postgraduate researchers helps identify barriers that technical teams may overlook, ensuring AI-enabled services promote equitable access and effective learning outcomes (WHO & UNICEF, 2022; NIST, 2023; UNESCO, 2021c).

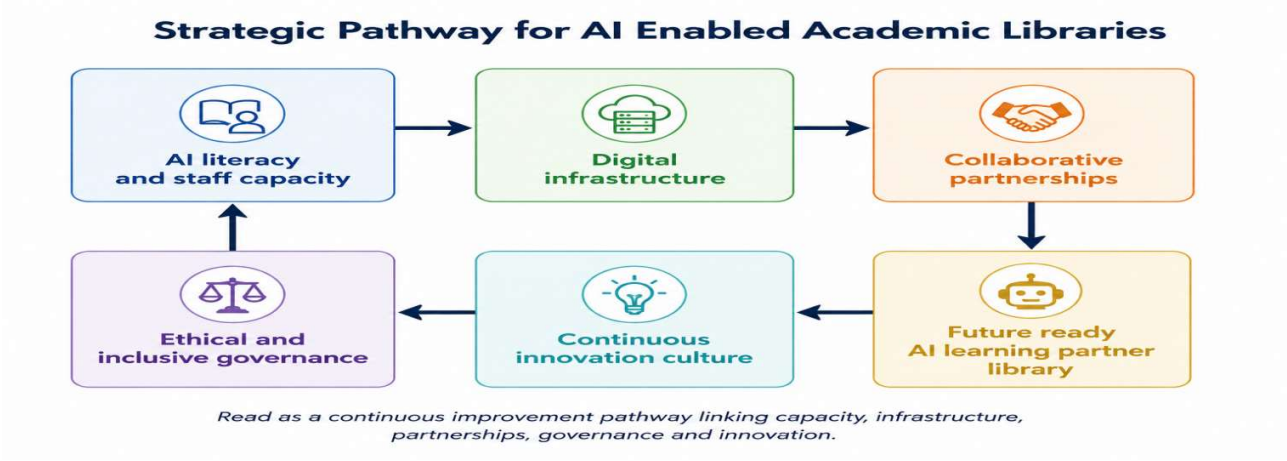

Figure 3: Strategic pathway for AI enabled academic libraries.

Thematic Synthesis and Discussion

The reviewed literature demonstrates a convergence of technological innovation, pedagogical transformation, and equity-focused practice in academic libraries. Libraries are increasingly transitioning from collection-centred institutions to intelligent, learner- and research-oriented knowledge ecosystems. This transformation extends beyond the digitalisation of print resources to a redefinition of library value. While libraries continue to safeguard quality and access, they now actively support learning, uphold research integrity, facilitate digital scholarship, and promote responsible participation in knowledge creation (Cox, Pinfield & Rutter, 2019; Hervieux & Wheatley, 2021). Such evolution aligns with the view that academic libraries must be fully embedded within the university's educational mission (Association of College and Research Libraries, 2017).

Artificial intelligence technologies such as intelligent discovery systems, chatbots, recommender systems, predictive analytics, automated metadata tools, assistive AI, and generative AI play a critical role in reshaping STEM library services. These tools enhance access to specialised STEM knowledge, reduce cognitive load, support research discovery, and provide personalised guidance. Their effectiveness depends on data quality, accessibility, user training, and ethical oversight (Concha, Palacios Zenteno & Tello Alfaro, 2024; Zawacki-Richter et al., 2019). Consequently, AI tools should be integrated within a governed learning ecosystem rather than deployed as isolated software solutions.

AI-enabled libraries contribute to inclusive and sustainable STEM education by providing adaptive discovery, accessible formats,

assistive technologies, multilingual support, low-bandwidth resources, and targeted learning guides. They also support sustainability through open science, research data sharing, STEM literacy, and innovation (CAST, 2024; WHO & UNICEF, 2022). These capacities strengthen the rationale for recognising academic libraries as strategic infrastructure for sustainable development. Effective STEM education extends beyond classroom instruction, requiring knowledge environments in which all learners can access, interpret, and apply scientific information (Mudaly, 2023; Xu & Ouyang, 2022).

Persistent barriers to AI integration include limited infrastructure, inadequate funding, skills gaps, ethical concerns, weak policy frameworks, and digital exclusion. These barriers are interrelated: insufficient funding constrains infrastructure; weak infrastructure undermines service reliability; limited staff training reduces adoption; inadequate policy increases ethical risks; and digital exclusion prevents learners from benefiting even when systems are available (ITU, 2023; World Bank, 2024). In the Global South, AI-enabled libraries must therefore be embedded within broader strategies for digital transformation, open science, and inclusive education. Ensuring future readiness requires a combination of capacity building, robust digital infrastructure, collaborative partnerships, ethical governance, and a culture of continuous innovation. Capacity building enables librarians to use infrastructure effectively, partnerships expand expertise, governance safeguards trust, and innovation ensures adaptability to technological change. A future-ready academic library is therefore defined not by the cost of software but by its educational purpose, commitment to inclusion, responsible implementation, and measurable impact (Bond et al., 2024; NIST, 2023; UNESCO, 2021c).

Table 5: Concise synthesis of reviewed evidence

Theme	Main finding	Implication for Global South STEM education
Library transformation	Libraries are moving from access control to learning and research partnership	Institutional strategy should place libraries within teaching, research and digital transformation planning
AI service domains	Discovery, reference, recommender systems, analytics, assistive AI and generative AI dominate practice	AI should be linked to curriculum needs, research integrity and user support
Inclusion	Accessibility, assistive technology and user centred design determine equity value	Services must work for disabled, rural, low income and linguistically diverse learners

Governance	Privacy, bias, transparency and human oversight shape trust	Libraries need local AI governance frameworks and procurement standards
Sustainability	Open science, shared infrastructure and capacity building reduce dependency	Consortia, open-source solutions and phased implementation improve feasibility

Conclusion

This paper has demonstrated that academic libraries in the Global South must be reconceptualised as AI learning partners to advance inclusive and sustainable STEM education. While STEM education is critical for sustainable development, access to high-quality resources, digital tools, and research support remain unequal. AI-enabled libraries can help reduce these disparities by enhancing resource discovery, providing personalised learning support, improving accessibility, strengthening research integrity, and fostering collaborative knowledge creation. However, the potential of AI will only be realised when libraries implement responsible governance, invest in infrastructure, develop staff capacity, and prioritise inclusion by design. The transition from traditional information gatekeeping to AI-supported learning partnership enhances, rather than diminishes, the professional value of librarians. Although AI can automate routine tasks such as search assistance, metadata management, and basic resource recommendations, it cannot replace the ethical judgment, pedagogical sensitivity, contextual understanding, and human care necessary for inclusive knowledge work. Librarians will increasingly play a central role as students and researchers navigate information overload, generative AI risks, misinformation, inaccessible platforms, and complex research environments. The continued relevance of the academic library depends on its ability to integrate technological innovation with human-centred services and research support.

For the Global South, the challenge is to adopt AI-enabled libraries thoughtfully, avoiding both technological pessimism and uncritical enthusiasm. Successful implementation requires realistic strategies that address infrastructure limitations, funding constraints, digital skills gaps, language diversity, disability inclusion, gender equity, local research visibility, and data rights. Libraries designed with accessibility, ethical governance, and open knowledge principles at their core can significantly advance educational equity, research excellence, and sustainable development. Consequently, academic libraries should occupy a central position in digital higher education policy,

institutional research strategy, and the broader transformation of STEM education.

Recommendations

The following recommendations are made based on the findings from the study:

1. Higher education institutions should invest in AI-enabled library infrastructure as part of core digital campus development rather than treating library technology as an optional service cost.
2. Academic libraries should develop AI literacy programmes for librarians, students and faculty, with specific modules on responsible generative AI use, source verification, research integrity and data ethics.
3. Governments and higher education regulators should formulate inclusive digital education policies that recognise academic libraries as strategic actors in STEM education, open science and national innovation.
4. Libraries should prioritise accessibility in all AI deployments by using Universal Design for Learning, assistive technologies, captioning, screen reader compatibility, mobile access and user co design.
5. University libraries should establish ethical AI governance frameworks that address privacy, consent, data retention, algorithmic bias, transparency, procurement standards and human oversight.
6. Academic libraries should create partnerships with STEM faculties, disability support units, information technology departments, technology firms, civil society organisations and development partners.
7. Library and Information Science schools should revise curricula to include AI literacy, digital accessibility, data stewardship, research analytics, open science and responsible technology governance.
8. Libraries in the Global South should explore open-source tools, consortia, shared infrastructure and low bandwidth solutions to reduce dependence on expensive proprietary systems.
9. Academic libraries should document and evaluate the impact of AI enabled services on STEM learning outcomes, research productivity, inclusion and user satisfaction.

Limitations and Future Research Direction

This paper is limited by its narrative review design and does not present primary institutional data from a specific university library. Future research should test the proposed framework through empirical studies in Global South universities, with attention to

user experience, cost effectiveness, disability inclusion, gender participation, rural access, research productivity and measurable STEM learning outcomes.

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