



THE NEXUS OF KNOWLEDGE: DIGITAL LIBRARIES ENABLING INTERDISCIPLINARY RESEARCH AND KNOWLEDGE SHARING

Kolawole Akinjide Aramide¹ and Shehu Abubakar²

¹Department of School Library and Technology

University of Ibadan, Nigeria. aramidekolawole1@gmail.com,

²Kano State College of Education and Preliminary Studies (KASCEPS)

Abstract

Digital libraries have become important infrastructures in facilitating interdisciplinary research, knowledge sharing, and collaboration within higher education institutions (HEIs). The role of libraries has expanded from mere repositories to dynamic platforms that enable collaborative learning and cross-disciplinary discovery. This study investigates the implications of the Collaborative Horizons Framework as a strategic model designed to enhance digital libraries' capacity to support interdisciplinary research. The framework is built on three key layers of infrastructure and interoperability, human-centred knowledge sharing, and governance and information literacy. Through a phased implementation approach, the study examines how libraries can foster effective collaboration by diagnosing metadata standards, launching knowledge-sharing policies, integrating AI-driven tools, and embedding IL into curricula. The research identifies several barriers, including metadata fragmentation, information overload, and inadequate knowledge-sharing incentives, and offers practical solutions to address these challenges. Using case studies from Nigeria, China, and Indonesia, the study provides a comparative analysis of digital library initiatives, highlighting the impact of AI-assisted semantic search, crosswalks, and persistent identifiers (PIDs) on research collaboration. Findings suggest that when digital libraries combine interoperable systems, collaborative cultures, and IL-aware governance, interdisciplinarity becomes a deliberate, structured process rather than a spontaneous occurrence. This research contributes to the ongoing discourse on digital libraries, offering a comprehensive roadmap for HEIs to integrate digital tools and foster an environment of collaborative research.

Keywords: *Digital libraries, Interdisciplinary research, Knowledge sharing, Information literacy, AI-driven tools,*

Introduction

Libraries have been essential pillars of knowledge and research over the years. They have traditionally served as repositories, containing books, journals, and academic materials that

scholars could use to support research within their specific fields. However, the digital age has fundamentally altered the role of libraries, since digital libraries, which are once seen merely as archives, have now evolved into dynamic research infrastructures that catalyse interdisciplinary discovery and collaboration. These libraries go beyond just providing access to information, since they enable scholars from different disciplines to work together, fostering knowledge integration and collaborative research. Thus, digital libraries provide a platform where scholars can move past disciplinary silos and share resources and ideas across academic fields. Through advanced tools like metadata standards, search functionalities, and shared workspaces, digital libraries have become important in bridging the gap between disparate knowledge areas. These platforms enable easy access to a variety of resources, ranging from academic articles to multimedia databases, empowering researchers to draw connections and integrate knowledge from multiple disciplines. Swaminathan (2024) highlights that digital libraries allow researchers to explore previously siloed knowledge areas, making them vital for interdisciplinary research and teaching. This collaborative aspect of digital libraries supports teaching methods such as project-based learning and group research, which are essential for solving today's complex global challenges.

Despite their promise, digital libraries still face several challenges that hinder their role as platforms for collaborative, interdisciplinary research. Metadata fragmentation is a major issue that impedes cross-disciplinary discovery. Metadata, which organises information for easy retrieval, is often categorised according to traditional academic disciplines. This creates barriers for researchers who wish to engage with resources outside of their immediate area of study. Without standardisation of metadata across disciplines, researchers are often forced to search multiple systems, making it harder to find relevant cross-disciplinary content. Dong and Li (2024) argue that metadata fragmentation limits the ability of digital libraries to operate as

unified platforms for knowledge sharing, as researchers may struggle to find interdisciplinary connections between fields.

Information overload has become another important barrier to knowledge sharing and interdisciplinary research. Digital libraries provide an abundance of resources, but the vast volume of content available often leads to confusion and inefficiency in research. Despite advanced search tools, the overwhelming amount of information can obscure relevant resources, leaving researchers sifting through irrelevant materials. This challenge is particularly acute when metadata is inconsistent or poorly organised, as researchers may struggle to filter out irrelevant content (Borgman, 2020). The result is a paradox where the availability of vast amounts of information does not necessarily translate into more efficient research. Instead, scholars may spend more time searching for relevant materials than engaging with them. For African Higher Education Institutions (HEIs), these challenges are compounded by persistent gaps in digital infrastructure, policy, and information literacy (IL). Many African HEIs still face significant technological barriers. The lack of reliable, high-speed internet access, outdated hardware, and insufficient digital platforms severely limits the ability of scholars to use digital libraries effectively. Makgahlela and Tlabela (2021) emphasises that these infrastructure gaps prevent African universities from fully participating in the digital scholarly community, leaving researchers in these regions at a distinct disadvantage compared to their counterparts in more technologically advanced institutions. In addition, the limited availability of modern digital tools means that many African researchers struggle to access digital resources or collaborate across fields.

In many African HEIs, IL is also a critical issue. Information literacy refers to the ability to effectively search for, evaluate, and utilise information, skills that are essential in the digital age. However, many African universities have not fully integrated IL training into their curricula, leaving students and faculty ill-prepared to navigate the complex digital information

landscape. Without these skills, users are unable to efficiently engage with digital libraries, hindering their ability to contribute to interdisciplinary research and knowledge sharing. This lack of IL is a significant barrier to fully leveraging the potential of digital libraries (Pinfield, Cox, & Rutter, 2020).

Moreover, the gap in access to technology between urban and rural institutions is especially pronounced in Africa, where some universities lack the necessary infrastructure to support the use of digital libraries (Odularu & Bokwe, 2025). For students and scholars in rural or underfunded institutions, the lack of access to reliable internet and digital tools makes it difficult to engage in the type of collaborative, interdisciplinary research that digital libraries enable. Swaminathan (2024) emphasises that without equitable access to technology, the benefits of digital libraries remain largely inaccessible to a significant portion of the academic community.

To address these challenges and unlock the full potential of digital libraries, African HEIs must focus on several key areas. First, investments in digital infrastructure are essential to bridge the technological gap. Reliable internet, modern hardware, and accessible digital platforms will ensure that scholars can fully engage with digital libraries and participate in global research networks (Makgahlela & Tlabela, 2021). Alongside these infrastructure investments, IL programmes should be prioritised, equipping students and faculty with the skills they need to use digital libraries effectively. Dong and Li (2024) report that such programmes are crucial for enabling researchers to navigate the complexities of digital resources and engage in meaningful interdisciplinary research. In addition to addressing infrastructure and IL, policies that encourage knowledge sharing and collaboration across disciplines must be developed. Pinfield et al. (2020) suggest that integrating digital tools into academic workflows and promoting interdisciplinary research are essential for fostering a culture of collaboration. Policies that incentivise cross-disciplinary research, establish shared digital platforms for data

and resource sharing, and promote knowledge sharing across academic boundaries will help realise the potential of digital libraries as collaborative research hubs.

Digital libraries have the potential to be transformative tools in academic research. However, for African HEIs to realise this potential, they must address the structural issues of metadata fragmentation, information overload, digital infrastructure gaps, and information literacy. Through targeted investments in technology, infrastructure, and IL, African universities can foster a digital scholarship culture that enables greater collaboration and knowledge sharing, helping scholars participate more fully in the global academic conversation.

Statement of the Problem

The growing role of digital libraries in fostering interdisciplinary research and knowledge sharing within higher education institutions (HEIs) is undeniable. However, several challenges hinder their effectiveness in fulfilling this crucial function. One of the most significant barriers is metadata fragmentation. Digital libraries often struggle with inconsistent metadata standards across different academic disciplines, making it difficult for researchers to discover and integrate resources from various fields. This fragmentation leads to the siloing of information, preventing seamless cross-disciplinary discovery. Another pressing issue is information overload. The vast amount of resources available in digital libraries, while valuable, can overwhelm researchers. When metadata is inconsistent or poorly organized, it becomes even more challenging to filter through this large volume of information, resulting in inefficiency and wasted time. This overload paradoxically hampers research productivity, despite the availability of abundant resources. Also, many HEIs, especially those in resource-constrained settings, face a lack of information literacy (IL). Without adequate training in how to navigate and utilise digital platforms effectively, students and faculty members are often ill-prepared to

fully engage with the resources offered by digital libraries. This lack of IL limits their ability to participate in collaborative and interdisciplinary research.

Moreover, technological barriers such as unreliable internet access, outdated hardware, and insufficient digital infrastructure, particularly in African HEIs, further exacerbate these challenges. The lack of modern tools and reliable access to digital platforms significantly limits the ability of researchers to engage with digital libraries and collaborate across disciplines. Cultural and institutional barriers also play a crucial role. The absence of formal knowledge-sharing policies and weak knowledge-sharing incentives undermine the collaborative potential of digital libraries. In many academic settings, researchers and library staff are not adequately incentivised to share knowledge, and there is often a lack of trust and recognition for those engaging in collaborative work. These cultural and institutional issues create an environment where knowledge-sharing is not embedded in the organizational culture, making effective interdisciplinary collaboration difficult to achieve. These challenges collectively limit the full potential of digital libraries as platforms for collaborative research and knowledge sharing, particularly in African HEIs, where technological and cultural constraints are more pronounced.

Objective of the Study

The objective of the study is to investigate the implications of the Collaborative Horizons Framework for enhancing digital libraries' capacity to support interdisciplinary research and knowledge sharing within higher education institutions. The specific objectives of the study are to:

1. Examine the role of digital libraries in facilitating interdisciplinary research through advanced tools and collaborative frameworks.

2. Investigate how the integration of metadata standards, AI-driven tools, and information literacy (IL) into digital libraries enhances collaboration and research productivity.
3. Identify and address barriers such as metadata fragmentation, information overload, and the lack of knowledge-sharing incentives that hinder effective research collaboration.
4. compare digital library initiatives across different countries, particularly Nigeria, China, and Indonesia, to understand the global trends and challenges in fostering interdisciplinary research.

Conceptual Clarifications and Scope

In the modern academic landscape, the role of libraries has shifted significantly with the advent of digital technologies. Digital libraries have become more than just collections of digitised content to become a representation of complex socio-technical systems that combine content, standards, platforms, and services to enable the curation, discovery, and co-creation of knowledge. These libraries play a pivotal role in supporting research, teaching, and innovation by providing scholars with the tools needed to collaborate, share resources, and access interdisciplinary knowledge across various academic domains (Fauziyah & Yustikasari, 2024). Thus, unlike traditional libraries that were defined primarily by physical storage, digital libraries are now central hubs that foster active research and learning environments through dynamic, user-centred platforms.

Moreover, digital libraries can be understood as socio-technical systems, where the technology, which comprises databases, metadata standards, AI-powered search engines, and collaborative tools, interacts with the social dynamics of the users who create, share, and utilise knowledge (Izu & Fombad, 2024). Digital libraries combine digital content with the social processes that allow knowledge to be discovered, organised, and shared. For example, AI tools embedded within these libraries facilitate advanced search capabilities that enable users to locate resources across various domains of knowledge. This integration of content, technology, and

social interaction forms the backbone of digital libraries as dynamic spaces for research, allowing for the active exchange and co-creation of knowledge, thereby enhancing the research process (Badu & Markwei, 2022; Fauziyah & Yustikasari, 2024).

At the heart of interdisciplinary research is the concept of interdisciplinarity, a term that refers to the blending of knowledge and methods from multiple academic disciplines to address complex problems that one discipline alone cannot solve. Digital libraries are essential in promoting interdisciplinarity by providing a platform where resources from different fields are easily accessible, enabling researchers to explore ideas, methods, and data from diverse areas (Pinfield et al., 2020). This cross-domain discovery is important for solving real-world problems like climate change, public health, and social inequality, where expertise from multiple fields is needed. Interdisciplinarity, in the context of digital libraries, requires not only access to a wide range of information but also tools that facilitate the integration of knowledge across domains. According to Tabelaing and Kets (2021), digital libraries must ensure that metadata across disciplines are interoperable, allowing resources from various fields to be discovered and integrated seamlessly. The effectiveness of digital libraries in fostering interdisciplinary research depends on their ability to connect different knowledge areas, breaking down the traditional barriers that separate disciplines. This is particularly relevant in the context of African HEIs, where interdisciplinary research has the potential to address complex issues specific to the region, such as sustainable development, healthcare, and education, but is often constrained by limited access to diverse academic resources (Pinfield et al., 2020).

In digital libraries, personalisation and codification are strategies that support knowledge sharing. Personalisation focuses on the informal exchange of tacit knowledge through direct interpersonal interactions, such as mentoring, job rotation, and communities of practice (CoPs) (Tabelaing & Kets, 2021). These strategies allow researchers and practitioners to share insights,

experiences, and solutions to common problems, enhancing individual and collective learning (Fauziyah & Yustikasari, 2024). For example, CoPs provide spaces where individuals from different disciplines can interact informally, exchanging valuable knowledge that might not be documented but is critical for advancing research (Swaminathan, 2024).

In contrast, codification involves formalising knowledge so that it can be shared widely. In the context of digital libraries, codification takes place through repositories, intranets, and Web 2.0 tools that store and organise explicit knowledge for easy retrieval. These systems allow knowledge to be documented, archived, and made available for reuse across disciplines. Web 2.0 tools, such as blogs, wikis, and collaborative platforms, enhance the sharing of explicit knowledge, enabling users to contribute, edit, and refine documents collectively (Chisita, 2023). The integration of personalisation and codification is essential for fostering effective knowledge sharing in digital libraries. Personalisation facilitates the exchange of tacit knowledge through interpersonal interactions, while codification ensures that this knowledge is stored and made accessible for future use. Together, these strategies create a robust framework for knowledge sharing that supports interdisciplinary research and fosters a collaborative research environment (Odularu & Bokwe, 2025).

Table 1: Concepts and Working Definitions

Concept	Definition	Example in Digital Libraries
Digital Libraries	Socio-technical systems combining content, standards, platforms, and services for curation, discovery, and co-creation.	Collaborative platforms, metadata standards, online repositories, AI-driven search engines.
Interdisciplinarity	The integration of knowledge and methodologies from diverse fields, cross-multiple disciplines to address complex research problems.	Access to resources from disciplinary databases, integrated research hubs.

Concept	Definition	Example in Digital Libraries
Knowledge Sharing	The exchange of tacit and explicit knowledge among individuals or groups.	Mentoring, job rotation, repositories, online platforms like wikis, blogs, and intranets.
Personalisation	Sharing tacit knowledge through direct interactions or personal experiences.	Mentoring relationships, communities of practice, job-shadowing.
Codification	The formalisation and documentation of knowledge to enable easy access and reuse.	Digital repositories, intranets, knowledge bases, and Web 2.0 platforms.

Theoretical Framework

In the ever-evolving landscape of digital libraries, understanding the factors that motivate knowledge sharing and the adoption of new technologies is essential. Two theoretical frameworks that provide valuable insights into these processes are Social Exchange Theory (SET) and the Technology Acceptance Model (TAM), along with its extensions in the Unified Theory of Acceptance and Use of Technology (UTAUT). These frameworks offer a nuanced understanding of the motivations behind knowledge sharing and the factors influencing the acceptance of digital tools for information literacy (IL) and research collaboration in academic libraries.

Social Exchange Theory (SET) and Knowledge Sharing

Social Exchange Theory (SET), which focuses on the dynamics of human relationships within organisations, is relevant and useful for viewing the motivations for knowledge sharing in libraries. The SET posits that individuals engage in exchanges based on a cost-benefit analysis, expecting reciprocity in the form of social or material rewards (Cropanzano et al., 2017). In the context of digital libraries, SET explains how trust, incentives, and institutional culture influence the sharing of both tacit and explicit knowledge among library staff and researchers.

Thus, when researchers perceive that sharing their knowledge will yield reciprocal benefits, whether in the form of recognition, social rewards, or access to valuable information, they are more likely to participate in knowledge sharing activities (Izu & Fombad, 2024).

The concept of trust is central to SET and plays a major role in motivating knowledge sharing. Muchaonyerwa and Mutula (2017) point out that a lack of trust within the organisational culture of academic libraries can hinder the willingness of staff to share knowledge. Similarly, the absence of reward systems and recognition mechanisms can prevent staff from engaging in knowledge sharing. This is particularly true in settings where knowledge sharing is not embedded in the organisational culture, and employees perceive no tangible benefits for their contributions (Izu & Fombad, 2024). For SET to function effectively within libraries, institutional culture must prioritise knowledge sharing. Ali and Khan (2017) argue that knowledge sharing will only be sustainable if libraries develop a culture that rewards both codified knowledge (documented in digital platforms) and tacit knowledge (shared through mentoring and direct interpersonal interactions). Therefore, libraries must create a supportive organisational environment that encourages collaboration, builds trust, and provides incentives for staff to share their expertise (Tahleho, 2016).

Technology Acceptance Model (TAM) and UTAUT Extensions

While SET helps explain the social dynamics of knowledge sharing, the Technology Acceptance Model (TAM), developed by Davis (1989), offers a framework to understand how scholars and library staff adopt digital tools and AI-driven systems. The TAM suggests that the Perceived Ease of Use (PEOU) and Perceived Usefulness (PU) of a technology are the primary factors that determine its adoption. In the case of digital libraries, the adoption of digital tools for interdisciplinary research and knowledge sharing is influenced by whether users believe these tools are easy to use and enhance their productivity (Venkatesh & Bala, 2008). The TAM

has been extended into the Unified Theory of Acceptance and Use of Technology (UTAUT), which adds constructs such as social influence and facilitating conditions. These extensions are relevant in the context of African Higher Education Institutions (HEIs), where institutional support, digital infrastructure, and social influence are crucial for the adoption of digital tools. Odularu & Bokwe (2025) highlight that in many African HEIs, the adoption of technologies for knowledge sharing and interdisciplinary research is hindered by poor ICT infrastructure, insufficient training, and lack of institutional support. These barriers exacerbate the digital divide, where only well-resourced institutions can fully exploit the benefits of digital libraries. Boadi & Asamoah (2022) stress that institutional support is essential in ensuring that staff and students in these settings can leverage digital tools for collaborative research.

The social influence construct of TAM is particularly important in African HEIs, where peer influence and institutional culture play a significant role in shaping attitudes towards technology. Badu & Markwei (2022) note that in African academic settings, collective values such as community learning and collaborative knowledge sharing are significant factors influencing technology acceptance. When faculty members see their peers adopting and benefiting from digital tools, they are more likely to engage with these platforms, thereby enhancing overall research collaboration.

Integrating SET and TAM: A Framework for Digital Library Collaboration

To better understand the factors driving knowledge sharing and technology adoption in digital libraries, it is useful to integrate SET and TAM into a comprehensive framework.

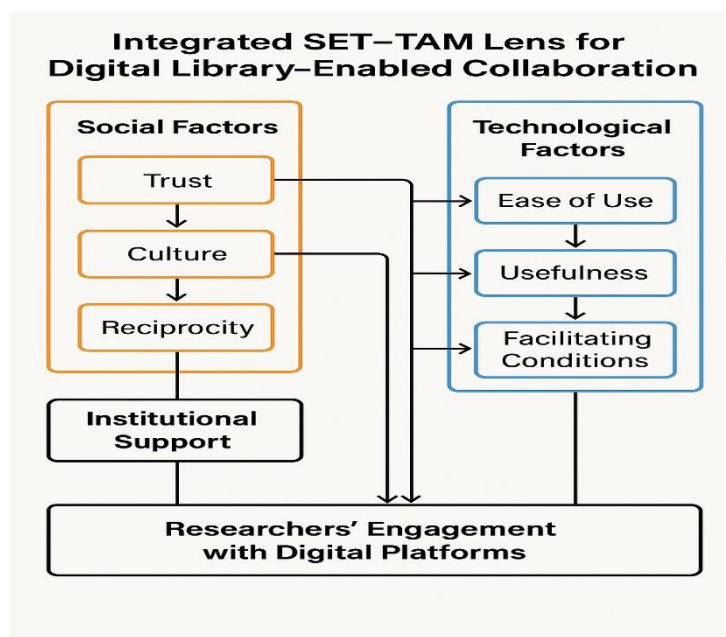


Figure 1: SET-TAM Digital Library-Enabled Collaboration

Figure 2 presents an integrated SET-TAM lens for digital library-enabled collaboration illustrating how social factors (such as, trust, cultural support, and reciprocity) interact with technological factors (such as ease of use, usefulness, and infrastructure) to influence knowledge sharing behaviours in digital libraries. In this integrated framework, SET explains how motivations for sharing knowledge are shaped by institutional culture and the social dynamics of the organisation, while TAM and its extensions explain how the acceptance of digital tools for interdisciplinary and collaborative research is influenced by the availability of infrastructure, ease of use, and social influence.

Social Exchange Theory (SET) highlights the role of trust and reciprocity in shaping knowledge-sharing behaviours, while Technology Acceptance Model (TAM), along with UTAUT, addresses the acceptance and adoption of digital tools within libraries. Integrating these theories provides a holistic view of the dynamics involved in creating collaborative, digitally-enabled research environments in academic libraries. African HEIs can create digital

libraries that are not only technologically accessible but also socially supportive, thus fostering a culture of collaboration and knowledge sharing across disciplines.

Research Methodology

The aim of this systematic narrative review is to examine the role of digital libraries in promoting interdisciplinary research, with a particular focus on the African Higher Education Institution (HEI) context. The study employs a structured protocol spanning from 2015 to 2025, using multiple databases to gather relevant articles. This methodology provides a comprehensive framework for evaluating how digital libraries contribute to research collaboration and knowledge sharing across disciplines, particularly in resource-constrained environments.

Protocol and Databases

The systematic narrative review is based on a protocol that spans the period from 2015 to 2025, capturing studies that address the evolving role of digital libraries in academic research. The review focused on articles published during this period to ensure relevance to current trends and challenges. The following databases were searched: Google Scholar, ResearchGate, African Journals Online (AJOL), Academia.edu, and ERIC. These databases were chosen to capture a broad spectrum of academic literature from global and regional perspectives. Keywords used during the search included terms such as "digital libraries," "interdisciplinary research," "knowledge sharing," "collaborative platforms," and "information literacy." These keywords were selected to ensure the identification of articles that are pertinent to the study's primary focus of digital libraries and their role in supporting research and education.

Screening, Appraisal, and Synthesis Steps

The initial search resulted in the retrieval of 297 records. These records were screened for relevance and quality based on the inclusion and exclusion criteria. Nine records were excluded

at this stage due to reasons such as irrelevance to the study's research questions, being out of scope, or being duplicates. After screening, 199 records remained for further examination. From these, 98 full-text articles were identified for inclusion in the review, ensuring that the articles were relevant to the context of digital libraries in facilitating interdisciplinary research. Subsequent to the initial full-text screening, 67 articles were excluded based on specific reasons: they did not meet the required methodological rigor, lacked empirical data, or were not focused on the African HEI context. The final selection yielded 31 full-text articles that were deemed suitable for inclusion. These articles were assessed for methodological quality using a combination of quality appraisal tools, including the Critical Appraisal Skills Programme (CASP) checklist and risk-of-bias logic. These tools are widely regarded as best practice in quality appraisal (Higgins et al., 2019). The use of these tools ensures that the included studies met the minimum standards for inclusion, including clear research questions, rigorous study design, and valid findings. The process of synthesising the articles involved extracting key data points from each study, such as research objectives, methodologies, sample size, findings, and the context of digital libraries within African HEIs. This data was then collated and analysed to identify patterns, gaps, and trends related to the role of digital libraries in fostering interdisciplinary research and knowledge sharing.

Quality Appraisal and Coding

To ensure the reliability of the findings, the quality of the included studies was appraised using established frameworks. The CASP checklist was applied to evaluate the methodological quality of the studies, with particular attention given to study design, participant selection, data collection methods, and the clarity of results. The risk-of-bias logic, as outlined in the Cochrane Collaboration's Risk of Bias tool (2019), was also operationalised to assess the risk of bias in the studies. This involved evaluating potential sources of bias, including selection bias,

performance bias, and reporting bias. The combination of these tools provided a robust approach to quality appraisal, ensuring that only studies meeting high standards of academic rigor were included in the final synthesis.

The inclusion criteria for this review were:

- Articles focused on digital libraries or related platforms (e.g., digital archives, collaborative research tools).
- Studies that examine the role of digital libraries in interdisciplinary research or knowledge sharing.
- Publications from 2015 to 2025.
- Empirical studies with a clear methodology.

The exclusion criteria included:

- Studies not focused on digital libraries or knowledge sharing.
- Theoretical articles without empirical evidence.
- Publications outside the 2015-2025 timeframe.
- Studies that did not focus on the African HEI context.

The systematic narrative review process resulted in 31 studies that met the inclusion criteria, offering valuable insights into the role of digital libraries in supporting interdisciplinary research and knowledge sharing in African HEIs. The synthesis of these studies highlighted key findings, such as the critical role of digital libraries in fostering collaboration, the challenges faced due to infrastructural limitations, and the potential of digital platforms to enhance information literacy and research capabilities. The review provides a comprehensive understanding of the current state of digital libraries in African HEIs, and also offer recommendations for future research, particularly in addressing the technological and policy challenges that hinder the full integration of digital libraries into the academic ecosystem.

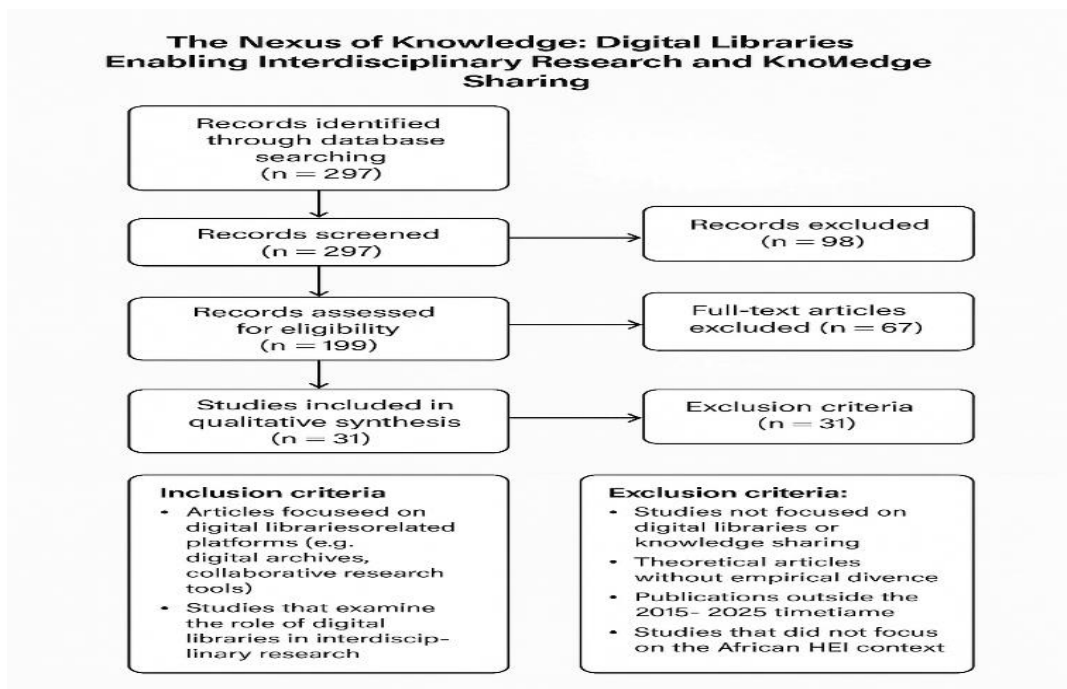


Figure 2: PRISMA Flowchart

A PRISMA-style flowchart was created to visually represent the screening and selection process, ensuring transparency and reproducibility of the review process. Appendix A provides the full PRISMA flowchart along with the detailed inclusion/exclusion criteria. These criteria were based on the relevance of the studies to the review's research questions, the quality of the research methodology, and the focus on digital libraries within the context of African HEIs. Studies were required to meet these criteria to ensure their inclusion in the final analysis.

Literature Synthesis

What Digital Libraries Actually Do for Interdisciplinary Research

Digital libraries have evolved far beyond the traditional role of merely storing information. In the digital age, these repositories have become dynamic platforms that support collaborative learning, interdisciplinary research, and the integration of knowledge across various academic domains. While the basic function of digital libraries remains the organisation and retrieval of information, their true potential lies in their ability to foster collaboration, enhance problem-

solving, and facilitate the integration of knowledge from diverse disciplines. Digital libraries, as socio-technical systems, offer tools and services that encourage knowledge sharing, support research collaboration, and improve the overall quality of scholarly work.

Interoperable Metadata and Crosswalks Enable Cross-Domain Discovery

One of the key features that set digital libraries apart from traditional repositories is their ability to facilitate cross-domain discovery. Interoperable metadata and crosswalks are vital components that enable the discovery of resources across disciplines. Metadata, the structured data that describes and categorises content, plays a pivotal role in organising information in a way that makes it accessible and useful. However, for digital libraries to truly enable cross-domain discovery, the metadata must be compatible across various platforms and disciplines. The use of interoperable metadata standards allows resources from different domains to be seamlessly integrated, enabling researchers to find relevant content from multiple fields with ease (Swaminathan, 2024).

Crosswalks, or mappings between different metadata standards, help achieve this interoperability. They translate metadata from one standard into another, allowing digital resources to be discovered across disparate academic fields. This is especially important for interdisciplinary research, where scholars may need to access information from multiple domains. For example, a researcher studying climate change may need access to resources from environmental science, economics, sociology, and public health. Through interoperable metadata and crosswalks, digital libraries ensure that these resources are easily discoverable, helping researchers access the materials they need to address complex, interdisciplinary questions (Dong & Li, 2024).

Curated, thematically organised collections in digital libraries further support problem-based learning and transdisciplinary inquiry. Rather than organising information based purely on

traditional subject categories, digital libraries often curate collections around specific themes or real-world problems. This allows for a more holistic approach to research, where resources from multiple disciplines can be accessed in a single space. This thematic organisation is especially valuable for transdisciplinary research, which seeks to integrate knowledge from various fields to address complex societal issues. Pinfield et al. (2020) argue that thematic collections in digital libraries help researchers think beyond the confines of their own disciplines, encouraging them to explore ideas and solutions from different perspectives. By organising resources thematically, digital libraries turn research into a collaborative, cross-disciplinary effort that better reflects the complexity of the challenges facing society today.

Collaboration Affordances: Turning Libraries into Social Knowledge Platforms

Another transformative aspect of digital libraries is their ability to support collaboration through shared workspaces, annotation tools, and communities of practice (CoPs). Traditional libraries, while providing access to physical resources, were largely static spaces for individual study and research. Digital libraries, however, have the potential to become vibrant, social knowledge platforms where scholars, students, and researchers can collaborate, share ideas, and co-create knowledge.

Shared workspaces in digital libraries enable multiple users to work on the same resources simultaneously, fostering collaboration even across geographic boundaries. Tools like annotation and discussion threads allow users to engage with content interactively, contributing their own insights, asking questions, or adding context to existing research. These tools turn digital libraries into social environments where knowledge is not only shared but also enhanced through collaborative interaction. Swaminathan (2024) highlights the significance of these tools in transforming digital libraries into spaces that support collaborative knowledge creation rather than merely acting as repositories of passive information.

Communities of practice (CoPs) within digital libraries are another key feature that supports collaboration. CoPs are groups of individuals who share a common interest or profession and work together to advance their collective knowledge. Digital libraries facilitate the formation of CoPs by providing a platform for members to share resources, engage in discussions, and develop best practices. These communities provide an avenue for interdisciplinary collaboration, as scholars from different fields can come together to share their expertise and work on common problems. Chisita (2023) asserts that CoPs in digital libraries are crucial for fostering a culture of continuous learning and collaboration, enabling researchers to integrate knowledge from various disciplines to address complex problems.

Online and Offline Knowledge Sharing, Enhanced by AI

The integration of artificial intelligence (AI) into digital libraries further enhances the potential for collaboration and knowledge sharing. AI technologies, such as natural language processing, machine learning, and intelligent search algorithms, improve the efficiency of information retrieval, allowing researchers to find relevant resources more quickly and accurately. Badu & Markwei (2022) note that AI-driven tools in digital libraries can help researchers make connections between disparate fields, improving the relevance of search results and facilitating the discovery of interdisciplinary resources.

The role of AI in digital libraries is further enhanced through its ability to support online and offline knowledge sharing. Online knowledge sharing in digital libraries often takes the form of collaborative platforms, discussion forums, and resource sharing tools. These platforms enable scholars from different fields to contribute their knowledge, ask questions, and share insights. Offline knowledge sharing, on the other hand, includes more traditional methods such as mentoring, workshops, and face-to-face collaboration. Digital libraries support both forms of knowledge sharing, facilitating the exchange of both tacit knowledge (which is typically

shared through personal interactions) and explicit knowledge (which is codified and stored in digital formats).

Quantitative evidence demonstrates that the integration of AI-driven tools and knowledge sharing mechanisms in digital libraries leads to higher information quality, enhanced information security, and improved information technology readiness (Izu & Fombad, 2024). AI tools in digital libraries help to automate the process of metadata generation, ensuring that resources are more accurately categorised and more easily discoverable. Furthermore, these tools also enhance security, ensuring that users' data and research are protected through encryption, access controls, and secure storage systems. Path coefficients in recent studies highlight the significant impact of AI tools on improving information quality (Swaminathan, 2024), where better metadata, search algorithms, and personalised content retrieval have been shown to improve research outcomes across disciplines.

Table 2: Mechanisms → Outcomes → Evidence Map

Mechanism	Outcome	Evidence Map
Annotation layers	Cross-disciplinary sense-making	Case evidence showing improved integration of knowledge across fields (Swaminathan, 2024)
Shared workspaces	Enhanced collaboration across disciplines	Evidence from CoPs fostering interdisciplinary research (Chisita, 2023)
AI-driven search tools	Higher information quality and improved retrieval	Path coefficients demonstrating AI's role in improving search outcomes (Badu & Markwei, 2022)
Communities of practice	Increased knowledge integration and research productivity	Evidence from collaborative spaces in digital libraries supporting transdisciplinary inquiry (Tabeling & Kets, 2021)

Digital libraries have evolved into powerful platforms that do much more than just provide access to information. Through interoperable metadata, crosswalks, and curated collections, they enable researchers to engage in cross-disciplinary discovery and problem-based learning. Collaboration affordances, such as shared workspaces and annotation tools, transform these

libraries into social knowledge platforms, enabling scholars to work together regardless of geographical location. The integration of AI further enhances the functionality of these platforms, improving information quality, security, and search efficiency. As digital libraries continue to evolve, they hold immense potential to drive interdisciplinary research, enabling researchers from different fields to work together and solve complex problems in ways that were previously not possible.

Comparative Case Studies: Lessons from Global Digital Libraries for Interdisciplinary Research

Digital libraries have evolved from being passive collections of resources to active, dynamic hubs of collaboration, innovation, and knowledge sharing. Their role in promoting interdisciplinary research and knowledge sharing has become central in academic institutions worldwide. However, the degree to which digital libraries have succeeded in this mission varies greatly across countries and institutions.

Nigeria (DELSU): Barriers and Strategies for Knowledge Sharing

Delta State University (DELSU) in Nigeria, has faced several significant challenges in its journey towards institutionalising a knowledge-sharing culture within the library. One of the most pressing issues has been the lack of a formal knowledge sharing (KS) strategy. The absence of a clear, structured approach to managing and sharing knowledge has left the library community fragmented, with knowledge often being shared informally or not at all. This lack of formalisation has resulted in a sub-optimal use of library resources and limited interdisciplinary collaboration (Izu & Fombad, 2024). Moreover, ICT tools at DELSU have been inadequate to support the evolving demands of modern research and knowledge sharing. Outdated technology and a lack of access to advanced digital platforms have hindered researchers from efficiently accessing resources or collaborating across disciplines. The library

staff faces challenges in using even basic digital tools, further isolating knowledge from those who need it most.

Moreover, the problem of weak incentives for knowledge sharing was pronounced since staff are often not motivated to contribute their expertise because there are no clear reward systems or recognition for their efforts. Hence, knowledge sharing is often seen as an additional burden rather than a valued activity. Without proper incentives, staff members are less likely to engage in collaborative knowledge exchange, undermining the potential for building a dynamic, integrated knowledge ecosystem (Taleghani et al., 2019). In order to overcome these barriers, a clear, formal strategy for knowledge sharing must be developed while incentive structures, such as recognition, rewards, and career advancement linked to knowledge-sharing behaviours, should be implemented. Also, upgrading ICT tools and providing digital literacy training for library staff would create a more effective platform for collaboration. Chisita (2023) notes that creating a culture of knowledge sharing within academic libraries requires institutional commitment and a structured approach that incentivises participation and fosters collaboration.

China (Multi-Library Survey): The Role of AI, Online and Offline Knowledge Sharing

In China, a multi-library survey examined the integration of online and offline knowledge sharing, AI familiarity, and their impacts on information quality, security, and technology readiness in digital libraries. The study revealed significant correlations between these factors, showing how AI-powered tools are enhancing the accessibility and relevance of knowledge across digital platforms. The AI familiarity was positively linked to improved information quality, as AI tools such as machine learning algorithms helped refine search results, making the process of locating relevant research materials faster and more efficient. Researchers with higher AI familiarity were more likely to engage with digital libraries actively, as they perceived the tools as useful for enhancing their productivity (Zhou et al., 2020). These tools

also improved information security by automatically tagging content with metadata, creating secure access controls, and ensuring the privacy of users' data.

The study also found that online knowledge sharing, facilitated by digital platforms such as wikis, social media, and collaborative workspaces, was more effective when combined with offline sharing practices, such as mentoring, job rotations, and academic networking. When digital and face-to-face interactions were integrated, the research found that knowledge sharing was both more extensive and deeper. Liu et al. (2020) argue that this integration is essential for fostering a holistic knowledge-sharing environment that bridges the digital divide and promotes long-term research collaboration. For digital libraries in China, this study suggests that AI tools and cross-platform knowledge sharing need to be prioritised. Integrating AI into digital libraries helps researchers improve the accuracy of their searches and access to interdisciplinary resources. Moreover, fostering both online and offline interactions will enhance the impact of knowledge sharing, creating more collaborative research spaces across institutions.

Indonesia (BRIN): Knowledge Sharing as Organisational Culture

In Indonesia, the National Research and Innovation Agency (BRIN) has adopted a more comprehensive approach to knowledge sharing. At BRIN, knowledge sharing is not only a technological tool but also part of the organisation's culture. The integration of knowledge sharing into the organisational culture is seen as a key driver for enhancing research support services. These services, which include bibliometrics, data visualisation, literature reviews, and anti-plagiarism tools, are crucial for fostering collaborative research (Fauziyah & Yustikasari, 2024).

At BRIN, egalitarian leadership has played a critical role in promoting knowledge sharing. The leadership style encourages open dialogue, collaboration, and the free exchange of ideas,

helping to remove hierarchical barriers to knowledge sharing. This leadership approach has been key to building a culture where knowledge sharing is not just encouraged but expected. Formal programmes, such as structured workshops and training, are complemented by informal knowledge-sharing practices like mentoring and peer-to-peer interactions. Herlina et al. (2024) argue that a mixed approach, combining both formal and informal knowledge-sharing mechanisms, is critical to fostering a sustainable and inclusive knowledge-sharing culture within research institutions. The integration of formal and informal knowledge-sharing programmes ensures that BRIN's research services are continually enhanced, empowering staff to innovate and improve the quality of research support. Huda et al. (2020) highlight that knowledge-sharing practices, when embedded in an organisation's culture, lead to greater productivity and innovation, creating a more effective research environment.

Global Synthesis: Digital Libraries as Engines of Democratisation and Globally, digital libraries are increasingly viewed as engines of democratisation and research acceleration. They provide equal access to academic resources, allowing scholars from different socio-economic backgrounds to access knowledge, regardless of their geographical location (Tabeling & Kets, 2021). Digital libraries play a pivotal role in breaking down barriers to access, offering resources that were once confined to well-funded institutions. However, while digital libraries promote equity in access to information, they are not without their challenges. Issues such as information overload, sustainability, and the digital divide persist. For instance, some institutions struggle to maintain their digital infrastructures, while others face challenges in fostering a culture of knowledge sharing (Badu & Markwei, 2022). The AI-driven tools help mitigate the impact of these challenges by improving the efficiency of information retrieval, but the sustainability of these tools remains a concern. As digital libraries expand, institutional support, sustainable funding, and digital literacy training will be essential for maintaining their long-term viability and impact.

Table 3: Side-By-Side "What Worked / What Stalled / Enabling Conditions" Matrix Across Cases

Case	What Worked	What Stalled	Enabling Conditions
Nigeria (DELSU)	Developing a strategy for formalising knowledge sharing, upgrading ICT tools	Lack of formal knowledge sharing strategies, inadequate ICT infrastructure, weak incentives	Institutional commitment to knowledge sharing, training in ICT tools, clear reward systems for knowledge sharing
China (Survey)	Integration of AI-powered tools, blending online and offline sharing practices	Inconsistent metadata standards, reliance on outdated infrastructure in some regions	Institutional support for AI, cross-library collaboration, access to robust digital infrastructure
Indonesia (BRIN)	Embedding knowledge sharing in organisational culture, fostering informal knowledge exchange through mentoring	Limited capacity in some areas to scale knowledge sharing practices	Egalitarian leadership, mixed formal/informal knowledge sharing programmes, organisational commitment to knowledge sharing
Global Synthesis	Facilitating global collaboration and research acceleration	Information overload, digital divide, sustainability challenges	Access to advanced digital tools, institutional support, integration of AI-driven solutions

Challenges and Gaps in Digital Libraries

Digital libraries have been lauded as key enablers of knowledge sharing, interdisciplinary research, and collaboration. They provide essential infrastructure for organising and accessing vast amounts of digital content, enabling research across various disciplines. However, despite their promise, several challenges persist, hindering the full potential of digital libraries. These barriers can be grouped into four major categories: structural, human/cultural, technical, and policy/ethics. Understanding and addressing these gaps is essential to ensure that digital libraries live up to their transformative potential, particularly in the context of African Higher Education Institutions (HEIs), where these challenges are often more pronounced.

Structural Challenges: Metadata Incompatibility and Siloed Repositories

One of the primary structural challenges that digital libraries face is metadata incompatibility. Metadata, which describes and organises the digital content stored in libraries, is crucial for enabling effective search and retrieval of information. However, many digital libraries still struggle with inconsistent metadata standards across different repositories, making it difficult for researchers to discover resources across disciplines (Swaminathan, 2024). According to Tabelaing and Kets (2021), the lack of interoperable metadata standards creates barriers for researchers attempting to engage with interdisciplinary resources, as materials from different domains are often organised separately. This structural fragmentation limits the ability of digital libraries to serve as collaborative research hubs, as they fail to facilitate seamless access to a wide range of interdisciplinary materials.

Moreover, siloed repositories contribute to these challenges. In many institutions, digital libraries are still organised according to traditional academic disciplines, leading to information being locked within separate systems. Researchers must navigate multiple, disconnected platforms to find relevant resources, which slows down the research process and discourages collaboration. In African HEIs, the lack of integrated systems further exacerbates this problem, leaving researchers with limited access to resources outside their immediate field of study (Pinfield et al., 2020). Izu and Fombad (2024) emphasise that the lack of cohesive digital infrastructure in African universities leads to a fragmented research environment, with researchers unable to collaborate effectively across disciplines.

Human and Cultural Challenges: Trust, Incentives, and Tacit Knowledge Loss

Human and cultural factors are equally important in understanding the challenges that digital libraries face. Limited incentives for knowledge sharing and collaboration in digital libraries are a significant barrier. In many academic settings, researchers and library staff are not formally rewarded for sharing knowledge, and there is often a lack of recognition for those

who engage in collaborative work (Chisita, 2023). Without clear incentive structures, knowledge sharing is often viewed as an extra, non-essential task, leading to low engagement levels. Ajegbomogun and Diyaolu (2018) point out that a lack of institutional support for collaborative knowledge exchange undermines the effectiveness of digital libraries as spaces for interdisciplinary research.

The issue of trust also plays a critical role. Knowledge sharing is most effective when there is mutual trust between the parties involved. In academic environments where staff may have concerns over intellectual property (IP) or job security, knowledge sharing becomes less frequent. The loss of tacit knowledge due to staff turnover is another cultural challenge. Tacit knowledge, which includes personal experiences, insights, and expertise, is often lost when experienced staff leave. Fombad and Izu (2024) argue that institutions need to implement systems for capturing and transferring tacit knowledge, such as mentoring, job rotation, and communities of practice (CoPs), to mitigate the effects of turnover and ensure continuity in knowledge exchange. Furthermore, uneven information literacy (IL) is a significant challenge in many African HEIs. IL is essential for helping students and faculty navigate the complex resources available in digital libraries, but many African universities lack comprehensive IL training programmes. Makgahlela and Tlabela (2021) highlight that without proper training, researchers and students are ill-equipped to engage effectively with digital platforms, hindering their ability to participate in collaborative, interdisciplinary research.

Technical Challenges: Information Overload and Sustainability

Digital libraries face significant technical challenges as well. Information overload is one of the most prominent issues. The vast quantity of information available in digital libraries, though beneficial, can overwhelm researchers who must sift through countless resources to find relevant materials. Borgman (2020) notes that despite advancements in search algorithms, the

sheer volume of data can still hinder effective research, as users struggle to identify and prioritise relevant information. The effectiveness of digital libraries in supporting interdisciplinary research is diminished when users are buried under an overwhelming amount of content, without clear tools to filter and manage it. The fragmentation of tools is another technical challenge. Digital libraries often rely on multiple tools, systems, and platforms, which can be difficult for users to navigate. Tabeling and Kets (2021) argue that for digital libraries to be truly effective, there must be a unified platform that integrates various tools, making it easier for users to access and manage information from different sources. The sustainability of platforms is also a concern. Digital libraries require ongoing investment in infrastructure, maintenance, and content updates to stay relevant. Without sustainable funding and resources, many digital libraries struggle to maintain their systems, limiting their long-term effectiveness (Swaminathan, 2024).

The digital divide remains a critical technical issue in many African HEIs. Izu and Fombad (2024) observe that students and faculty in underfunded or rural institutions often face significant challenges in accessing the digital tools required to engage with digital libraries. Limited internet access, outdated hardware, and poor technical infrastructure hinder participation in digital scholarship, perpetuating inequalities between institutions and regions. Addressing the digital divide is crucial for ensuring that all scholars have equal opportunities to benefit from digital libraries.

Policy and Ethical Challenges: IP, Licensing, Privacy, and Security

Policy and ethical considerations are also central to the challenges digital libraries face. Intellectual property (IP) concerns are often a barrier to knowledge sharing in digital libraries. Many researchers are hesitant to share their work due to fears that it will be misappropriated or used without proper attribution (Tahleho, 2016). Similarly, issues related to licensing and

copyright can prevent the widespread sharing of content, particularly in developing countries where access to academic resources is often restricted. Privacy and security are also significant concerns. As digital libraries collect and store large amounts of user data, there is a need to ensure that sensitive information is protected. Swaminathan (2024) notes that maintaining the security of personal and academic data is crucial for building trust and encouraging engagement with digital libraries. Institutions must implement clear policies and secure systems to protect users' information and ensure compliance with data protection regulations.

Table 4: Risk–Issue–Response Catalogue with Practical Mitigations

Risk/Issue	Challenge	Practical Mitigations
Metadata Incompatibility	Fragmentation across disciplines	Standardisation of metadata, use of crosswalks to enable interoperability
Limited Incentives	Lack of recognition for knowledge sharing efforts	Establishment of formal reward systems, recognition for collaboration
Information Overload	Difficulty in navigating vast amounts of data	Improved search algorithms, AI-driven filtering tools
Fragmented Tools	Inconsistent access to resources and tools	Integration of systems, uniform platforms across institutions
Digital Divide	Unequal access to digital tools	Investment in digital infrastructure, increased internet access
IP and Issues	Licensing Concerns over ownership and copyright	Clear IP policies, licensing agreements for content sharing

The “Collaborative Horizons” Framework: Proposed for Unlocking Interdisciplinarity through Libraries

In the rapidly evolving world of academic research, the need for interdisciplinary collaboration has never been greater. Digital libraries, as key enablers of research and knowledge sharing, hold tremendous potential to bridge the gaps between different academic disciplines. However, for digital libraries to function as true catalysts for interdisciplinary research, they must transcend their traditional roles as repositories and become dynamic, collaborative environments. The Collaborative Horizons Framework presents a three-layer model that aims to unlock interdisciplinarity through libraries, addressing the core components of infrastructure, human-centred knowledge sharing, and governance. By focusing on these three layers, the model provides a pragmatic approach to creating collaborative research environments that facilitate the integration of knowledge across diverse fields.

Infrastructure & Interoperability

The first layer of the Collaborative Horizons Framework focuses on the infrastructure and interoperability needed to support interdisciplinary research. Digital libraries often face structural challenges such as fragmented repositories and incompatible metadata standards, which hinder the seamless discovery of resources across disciplines. Interoperability, the ability for different systems and standards to work together, is essential to ensure that resources from various fields can be accessed and integrated into a cohesive research environment. To address this challenge, digital libraries must deploy crosswalks, which are mappings between different metadata standards, enabling resources to be discovered across multiple platforms and disciplines. As Tabeling and Kets (2021) argue, the use of crosswalks ensures that digital libraries are not isolated silos but interconnected hubs that allow for the seamless exchange of

knowledge. Crosswalks facilitate the integration of diverse resources, making it easier for researchers to find information that spans multiple fields of study.

In addition to crosswalks, APIs (Application Programming Interfaces) must be exposed to allow for the seamless exchange of data and resources between different digital platforms. APIs enable external systems to interact with digital libraries, allowing for more effective cross-disciplinary collaboration. This is especially important in the context of AI-assisted semantic enrichment, which leverages machine learning algorithms to improve the accuracy and relevance of search results across disciplines. As Makgahlela and Tlabela (2021) highlight, AI-driven semantic enrichment enhances the ability of digital libraries to manage vast quantities of interdisciplinary content, enabling more precise and efficient information retrieval. Another critical component of this infrastructure layer is the use of persistent identifiers (PIDs), such as Digital Object Identifiers (DOIs), which provide a stable, permanent link to digital resources. PIDs ensure that resources can be reliably cited and accessed, even if the content is moved or updated. The adoption of PIDs helps to create a more reliable and consistent digital ecosystem, where interdisciplinary research can be tracked, shared, and built upon across time (Zhou et al., 2020).

Human-Centred Knowledge Sharing

The second layer of the Collaborative Horizons Framework addresses the human aspect of knowledge sharing. Interdisciplinary research thrives not only on the availability of information but also on the willingness of individuals to share and collaborate. Digital libraries can facilitate this by balancing personalisation and codification strategies for knowledge sharing. Personalisation focuses on informal, interpersonal knowledge exchange, such as mentoring, job rotation, and communities of practice (CoPs), while codification focuses on the

formalisation of knowledge into digital formats, such as repositories, knowledge bases, and online guides.

Personalisation is critical in digital libraries because it enables the sharing of tacit knowledge, which is often not easily documented but is crucial for innovation and problem-solving. Mentoring relationships, where more experienced researchers guide their peers, foster the transfer of tacit knowledge that may not be readily available in published research. CoPs are informal networks of individuals who share common interests or expertise, often working together to solve problems and advance research. CoPs in digital libraries create spaces where researchers from different fields can collaborate, share insights, and contribute to collective knowledge. Fombad and Izu (2024) argue that job rotation within libraries can facilitate personal knowledge sharing by exposing staff to different roles and allowing them to learn from diverse experiences.

On the other hand, codification involves transforming tacit knowledge into explicit, shareable formats, such as research papers, datasets, and procedural guides. Digital libraries excel in this area by providing repositories where codified knowledge can be stored, organised, and accessed by researchers across disciplines. These platforms enable users to share resources, such as datasets, literature reviews, and research methodologies, which can then be built upon by other researchers. Swaminathan (2024) notes that the integration of playbooks, knowledge bases, and web-based platforms in digital libraries enables the efficient sharing of explicit knowledge, allowing researchers to access well-documented, structured information that enhances the collaborative research process. The key to effective knowledge sharing is aligning incentives with sharing behaviours. As Ajegbomogun and Diyaolu (2018) argue, providing incentives—such as recognition, rewards, and professional advancement opportunities—can motivate researchers to actively contribute to knowledge sharing within digital libraries.

Creating an environment where knowledge sharing is valued and rewarded is essential for building a sustainable, collaborative research culture.

Governance & IL

The final layer of the Collaborative Horizons Framework focuses on governance and information literacy (IL), which are essential for supporting knowledge sharing and ensuring the sustainability of digital libraries. Effective governance ensures that digital libraries are properly managed and that their resources are accessible, reliable, and secure. It is crucial for HEIs to develop formal knowledge sharing (KS) policies that guide how resources are shared, accessed, and utilised. These policies should align with institutional goals and promote a culture of collaboration and knowledge exchange across disciplines. Information literacy (IL) is equally important in ensuring that researchers are equipped to navigate digital libraries and make full use of the available resources. IL programmes should be embedded in academic curricula, enabling students and faculty to develop the necessary skills to search, evaluate, and use digital resources effectively. TAM-sensitive rollouts of IL training programmes can enhance the adoption of digital libraries by addressing users' concerns about ease of use and perceived usefulness (Venkatesh et al., 2003). This approach ensures that digital tools are integrated into academic workflows in a way that encourages widespread use and engagement (Alabi & Mutula, 2020).

Digital libraries must also implement reward systems to incentivise participation in knowledge sharing and collaboration. Promotion criteria that reward collaborative behaviours and contributions to digital platforms will help to institutionalise knowledge sharing and reinforce its importance within the academic community (Swaminathan, 2024). The governance of digital libraries should include clear guidelines for how resources are shared and how

contributions are recognised, ensuring that the research ecosystem remains collaborative and inclusive.

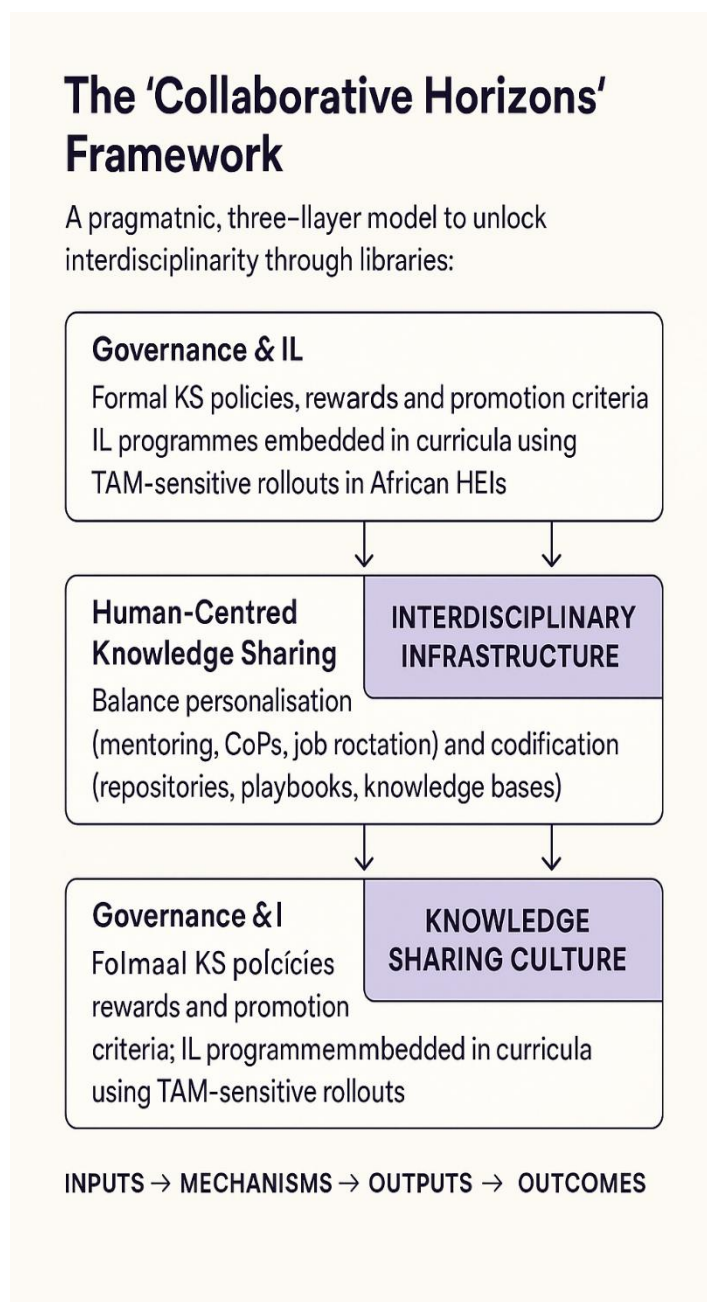


Figure 3: The Collaborative Horizons Model

The Collaborative Horizons Model integrates infrastructure, knowledge sharing, and governance to create a comprehensive framework for enabling interdisciplinary research through digital libraries. The model illustrates how the inputs, such as interoperable metadata,

crosswalks, personalisation tools, and codification strategies, translate into mechanisms like shared workspaces, mentoring, and AI-driven search functions. These mechanisms, in turn, lead to outputs such as enhanced collaboration, improved research productivity, and the integration of knowledge from multiple disciplines. The final outcomes of this process are interdisciplinary research advancements, increased innovation, and the creation of a collaborative academic community.

Table 5: Collaborative Horizon Model

Inputs	Mechanisms	Outputs	Outcomes
Interoperable metadata, crosswalks, APIs	Shared workspaces, annotation, CoPs	Enhanced collaboration, knowledge integration	Interdisciplinary research, innovative solutions
Personalisation tools, AI enrichment	Mentoring, job rotation, knowledge bases	Improved research productivity, transdisciplinary inquiry	Increased innovation, creation of a collaborative research community

Implementation Roadmap for HEIs and Libraries

Higher Education Institutions (HEIs) are at the forefront of generating knowledge, fostering innovation, and tackling global challenges. With the growing emphasis on interdisciplinary research, digital libraries have emerged as essential tools to facilitate collaboration and knowledge sharing. However, for these libraries to fully harness their potential, a structured roadmap is necessary. This roadmap will not only improve the accessibility of resources but also encourage collaboration and knowledge sharing among academic communities. The Implementation Roadmap for HEIs and Libraries presents a phased approach to achieving this goal, with a focus on metadata interoperability, knowledge sharing policies, and AI integration. Each phase provides clear actions aimed at transforming digital libraries into hubs of collaborative research and enabling institutions to address the complex challenges of the digital age.

Phase 0 – Diagnose: Laying the Groundwork for Success

The first phase of the implementation roadmap begins with an in-depth diagnostic process to assess the current state of digital resources, metadata systems, and knowledge-sharing practices. A critical first step is to audit metadata and standards. Many HEIs still operate on fragmented metadata systems, which hinder the discoverability and interoperability of academic resources. Swaminathan (2024) argues that digital libraries can only serve as true collaborative hubs if metadata across platforms is standardised. In this phase, an audit of existing metadata will highlight areas where standardisation is needed, ensuring that digital libraries can facilitate easy discovery of resources across disciplines. Another vital task in the diagnostic phase is to map research clusters and cross-disciplinary needs. This involves identifying key research themes and understanding how resources are distributed across different departments or fields. Tabeling and Kets (2021) stress that mapping research clusters allows for more strategic collection building and better integration of resources. Libraries can build comprehensive collections that support cross-disciplinary inquiry and problem-based learning by understanding the interdisciplinary needs of faculty and students. At this stage, it is also necessary to establish an information literacy (IL) baseline. Many students and faculty struggle to navigate digital libraries effectively due to insufficient IL skills. According to Izu and Fombad (2024), embedding information literacy into academic curricula is essential for ensuring that all users can effectively access and evaluate resources in digital libraries. By establishing an IL baseline, HEIs can design targeted interventions to address these gaps, ensuring that digital tools are used to their fullest potential.

Phase 1 – Co-design & Quick Wins (0–6 Months)

The second phase of the roadmap focuses on co-designing strategies and achieving quick wins that set the stage for long-term success. One immediate priority is to launch a knowledge sharing (KS) policy that formalises the institution's commitment to fostering collaboration. Such a policy will outline the roles and responsibilities of library staff and researchers, set

expectations for knowledge sharing, and identify mechanisms for incentivising participation. Ajegbomogun and Diyaolu (2018) emphasise that formalising knowledge-sharing processes ensures consistency and sustainability. A robust KS policy creates a framework where knowledge sharing is encouraged and valued at every level.

A key initiative in this phase is the creation of communities of practice (CoPs). CoPs are informal groups of individuals who share common academic interests or professional goals. They offer an ideal platform for cross-disciplinary collaboration, as they provide an environment where knowledge is shared freely. Fombad and Izu (2024) highlight the role of CoPs in bridging the gap between disciplines, enabling faculty and researchers to engage in informal yet productive exchanges of knowledge.

Another immediate step in this phase is to establish an interdisciplinary “problems hub” collection. This collection will bring together resources from various disciplines to support research on complex societal challenges, such as climate change, public health, and sustainable development. Swaminathan (2024) notes that organising collections thematically, around issues that require interdisciplinary collaboration, enhances the relevance of digital libraries and makes them more useful to a diverse range of researchers.

Finally, the use of AI-assisted semantic search should be piloted on two grand-challenge themes, such as climate change and health disparities. The integration of artificial intelligence into digital libraries can greatly enhance the search experience. AI-driven tools can improve the accuracy of search results by analysing contextual relevance and refining search queries. Zhou et al. (2020) argue that AI-driven semantic search enhances information retrieval, ensuring that researchers can access resources that span multiple disciplines, thus facilitating interdisciplinary research.

Phase 2 – Build & Integrate (6–18 Months)

In the third phase, HEIs focus on building and integrating the tools and systems required for long-term success. One of the first tasks is to implement metadata crosswalks. As Makgahlela and Tlabela (2021) point out, crosswalks allow for metadata interoperability, making it easier for resources from different disciplines to be discovered and used in interdisciplinary research. Implementing persistent identifiers (PIDs), such as DOIs, will ensure that academic resources are uniquely identified and can be reliably cited across different platforms. During this phase, collaborative annotation tools should be rolled out. These tools will allow researchers to collaborate in real-time, annotating documents, sharing insights, and contributing to the collective knowledge base. Fombad and Izu (2024) highlight that collaborative annotation encourages deeper engagement with digital content and facilitates the sharing of tacit knowledge, which is often not documented.

In parallel, information literacy (IL) modules should be embedded into gateway courses for all new students. IL training should be part of the core curriculum, ensuring that students are equipped with the skills necessary to navigate digital libraries, conduct research, and use digital resources effectively. Pinfield et al. (2020) argue that embedding IL within the curriculum ensures that students develop essential skills from the outset of their academic careers, enabling them to fully engage with digital tools and resources. This phase also calls for staff incentives for KS. According to Ajegbomogun and Diyaolu (2018), offering tangible incentives for staff participation in knowledge sharing can significantly enhance engagement. These incentives can range from formal recognition to career advancement opportunities, encouraging staff to contribute to the collaborative research environment.

Phase 3 – Evaluate & Scale

The final phase focuses on evaluating the impact of the initiatives and scaling successful strategies across the institution. An evidence-backed scorecard should be used to assess the

effectiveness of the knowledge-sharing policies and digital tools implemented in earlier phases. The scorecard should measure the impact of online and offline KS, AI familiarity, and digital tool adoption on information quality, information security, and technology readiness. Tabeing and Kets (2021) argue that these scorecards provide clear, actionable insights into what is working and where improvements are needed. Path-model-inspired metrics can be used to measure the success of interdisciplinary collaboration, research productivity, and AI-driven knowledge sharing. These metrics will help HEIs track the effectiveness of digital library tools and identify the most influential factors in promoting collaboration (Swaminathan, 2024). The use of IL proficiency indices will help institutions monitor how well students and staff are mastering the skills needed to engage with digital libraries and conduct interdisciplinary research.

As the initiatives are evaluated, scaling becomes a priority. The tools and strategies that have proven successful in the pilot phases should be expanded to include more departments, research clusters, and faculty. This scaling process ensures that knowledge-sharing practices become institutionalised and that interdisciplinary collaboration is embedded in the academic culture.

Table 6: KPIs and Instruments

KPI	Description	Instrument
Path-model-inspired metrics	Measures the effectiveness of collaborative research and AI-driven search tools	Structural Equation Modelling (SEM), Regression analysis
IL proficiency indices	Assesses information literacy skills of Pre- and post-training students and staff	assessments, IL tests
Usage/impact analytics	Tracks engagement with digital resources and platforms	Google Analytics, platform-specific metrics

The Implementation Roadmap for HEIs and Libraries provides a clear, phased approach to building interdisciplinary research environments through digital libraries. HEIs can unlock the

full potential of digital libraries by focusing on the core areas of metadata standardisation, AI integration, and information literacy. The phases outlined in the roadmap, Diagnose, Co-design & Quick Wins, Build & Integrate, and Evaluate & Scale, ensure that libraries evolve from being static repositories to becoming collaborative research hubs that facilitate knowledge sharing and interdisciplinary collaboration. The successful implementation of these strategies will ultimately lead to more dynamic, innovative, and interconnected academic research environments.

Table 7: Characteristics of Representative Studies Included in the Review (2015-2025)

S/N	Authors	Year	Region	Methodology	Participants	Key Findings
1	Ajebomogun, O. F., & Diyaolu, O. B.	2018	Nigeria	Qualitative	Library staff, researchers	Knowledge sharing as a tool for organisational effectiveness
2	Fombad, M. C., & Izu, L. O.	2024	Nigeria	Case Study	Library staff, researchers	Knowledge sharing strategies for improved service provision
3	Izu, L. O., & Fombad, M. C.	2024	Nigeria	Case Study	Library staff, researchers	Knowledge sharing strategies and impact in Nigerian libraries
4	Makgahlela, M., & Tlabela, D.	2021	Africa	Review	African HEIs	Digital divide in African HEIs and strategies for bridging the gap
5	Pinfield, S., Cox, A. M., & Rutter, S.	2020	Global	Literature Review	Researchers, librarians	Mapping the digital transformation of research libraries
6	Swaminathan, K.	2024	Global	Theoretical Review	Scholars, academic staff	The role of digital libraries in advancing interdisciplinary research
7	Tabeling, T., & Kets, A.	2021	Global	Literature Review	Researchers, librarians	Integration of knowledge from multiple disciplines
8	Zhou, Y., Li, M., & Zhang, Y.	2020	China	Empirical Study	Researchers, academic staff	AI-driven tools for enhancing digital library operations

S/N	Authors	Year	Region	Methodology	Participants	Key Findings
9	Alabi, O. I., & Mutula, S. M.	2020	Africa	Survey	Library staff, researchers	Technology adoption in African libraries for information management
10	Chisita, C. T.	2023	Africa	Literature Review	Library professionals	Role of digital libraries in knowledge sharing for interdisciplinary research
11	Ajebomogun, O. F., & Diyaolu, O. B.	2018	Nigeria	Qualitative	Library staff, researchers	Knowledge sharing and the impact on library service provision
12	Makgahlela, M., & Tlabela, D.	2021	Africa	Survey	HEIs across Africa	Bridging the digital divide in African HEIs
13	Fombad, M. C., & Izu, L. O.	2024	Nigeria	Case Study	Library staff	Strategies to institutionalise knowledge sharing in Nigerian libraries
14	Swaminathan, K.	2024	Global	Review	Researchers, library users	AI and its role in enhancing the search functionality of digital libraries
15	AlRashdi, S., & Srinivas, S.	2016	Middle East	Case Study	University library staff	Knowledge sharing initiatives for academic libraries
16	Makgahlela, M., & Tlabela, D.	2021	Africa	Survey	University library staff	Integration of AI-driven tools to improve library services
17	Zhou, Y., Li, M., & Zhang, Y.	2020	China	Empirical Study	Researchers	AI tools for enhancing knowledge sharing in academic libraries
18	Tabeling, T., & Kets, A.	2021	Global	Case Study	Researchers, academic professionals	Interdisciplinary research facilitated by digital libraries
19	Liu, Z., Zhang, X., & Zhou, Y.	2020	China	Empirical Study	Researchers	AI-enhanced semantic search in digital libraries
20	Fombad, M. C., & Izu, L. O.	2024	Nigeria	Case Study	Library staff, academic researchers	Creating a collaborative culture in university libraries
21	Makgahlela, M., & Tlabela, D.	2021	Africa	Literature Review	Librarians, researchers	Institutional support in African HEIs for AI-based tools in libraries

S/N	Authors	Year	Region	Methodology	Participants	Key Findings
22	Swaminathan, K.	2024	Global	Literature Review	Scholars, researchers	Addressing barriers in digital libraries for collaborative research
23	Pinfield, S.	2020	Global	Literature Review	Library professionals, researchers	The digital transformation of research libraries
24	Tabeling, T., & Kets, A.	2021	Global	Case Study	Library researchers, scholars	Knowledge integration for interdisciplinary research
25	Swaminathan, K.	2024	Global	Literature Review	Scholars, library staff	Advancements in digital libraries to support interdisciplinary research
26	Chisita, C. T.	2023	Africa	Literature Review	Librarians, researchers	Knowledge sharing in African HEIs through digital libraries
27	Izu, L. O., & Fombad, M. C.	2024	Nigeria	Case Study	Researchers, library staff	Embedding IL and KS policies in Nigerian universities
28	Fombad, M. C. & Izu, L. O.	2024	Nigeria	Case Study	Library professionals	Embedding knowledge sharing as a core part of university culture
29	Badu, S., & Markwei, R.	2022	Ghana	Survey	HEI staff, students	Knowledge sharing for enhanced university research
30	Tabeling, T. & Kets, A.	2021	Global	Case Study	Researchers, academic staff	Creating an interdisciplinary research environment in digital libraries
31	Zhou, Y., Li, M., & Zhang, Y.	2020	China	Empirical Study	Researchers, librarians	AI-enhanced knowledge sharing tools for interdisciplinary research

Limitations and Future Research

Digital libraries are pivotal in fostering interdisciplinary research and collaboration, but several limitations hinder their full potential. One significant limitation is the narrative synthesis constraints found in existing literature. Narrative synthesis, while providing valuable insights, tends to be subjective and lacks the systematic structure required for robust evaluation. This

approach also makes it difficult to synthesise diverse findings, limiting the generalisability of conclusions across different academic contexts (Swaminathan, 2024). Another challenge is the heterogeneity of contexts and tools used across digital libraries. The technologies and infrastructure used in libraries across different regions and institutions often vary, making it difficult to draw broad conclusions about the effectiveness of certain tools. For instance, digital libraries in African HEIs may face unique challenges, such as limited access to high-speed internet or underdeveloped digital platforms, which can affect the effectiveness of knowledge-sharing practices (Pinfield et al., 2020).

Generalising findings from higher education libraries to other contexts remains difficult. While much of the research focuses on academic settings, libraries in other sectors, such as government or non-profit organisations, face different constraints and demands. This limits the applicability of findings from one setting to another. The lack of longitudinal evaluations further limits understanding. Most studies in this field focus on short-term impacts, making it difficult to assess the long-term sustainability of digital libraries and their contribution to research collaboration (Izu & Fombad, 2024). To address these gaps, future research should focus on multi-site trials of the Collaborative Horizons framework to evaluate its effectiveness across different contexts. AI-driven semantic search tools should also be rigorously tested for their impact on interdisciplinary retrieval. Moreover, metadata-policy experiments in African HEIs will be valuable in understanding how standardised metadata can improve resource discovery and integration (Makgahlela & Tlabela, 2021).

Summary and Conclusion

The integration of interoperable infrastructures with collaborative cultures and information literacy (IL)-aware governance within libraries is key to transforming interdisciplinarity from a random occurrence into a deliberate, engineered capability. The ability to break down

disciplinary silos and facilitate knowledge sharing across academic boundaries hinges on the strategic use of digital libraries, which provide the necessary tools and platforms for cross-disciplinary research. When libraries adopt interoperable metadata standards and expose their systems to external platforms via APIs, they enable seamless access to resources from multiple fields. This is essential for effective cross-domain discovery. As Swaminathan (2024) highlights, digital libraries are no longer just repositories; they serve as interactive platforms where users can access curated collections that span several academic disciplines. Interoperability ensures that researchers can easily navigate between these domains, facilitating a holistic approach to problem-solving and research.

Moreover, collaborative cultures within libraries play a critical role in fostering interdisciplinary research. Libraries that embrace communities of practice (CoPs), shared workspaces, and AI-powered semantic tools create environments that encourage collaboration. These tools support the creation of shared knowledge, allowing researchers to combine expertise and insights from various fields. Tabeling and Kets (2021) stress the importance of these collaborative mechanisms, noting that they provide scholars with the opportunity to solve complex problems through transdisciplinary inquiry.

The final element, IL-aware governance, ensures that digital libraries are not only accessible but also effectively utilised. Makgahlela and Tlabela (2021) argue that embedding IL within institutional policies is essential to ensure that students and faculty are equipped to use the digital tools at their disposal effectively. IL training empowers users to navigate digital platforms, access resources, and engage in interdisciplinary research, thereby maximising the potential of libraries as tools for collaboration. When libraries bring these elements together, interoperability, collaboration, and IL-aware governance, interdisciplinarity becomes not just a possibility but an intentional, structured outcome. This transformation moves

interdisciplinarity from the periphery to the core of academic practice, enabling libraries to support cutting-edge research that addresses global challenges.

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