22

MULTILINGUAL CONVERSATIONAL AI SYSTEMS FOR ENHANCING ACCESS TO INDIGENOUS KNOWLEDGE IN ACADEMIC LIBRARIES IN SOUTHEAST NIGERIA

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Abstract

***Purpose**: This study developed and integrated conversational artificial intelligence (AI) into academic library systems. This novel approach aimed to bridging linguistic and cultural barriers in information access, particularly in underserved regions. This study presents the design, development, and evaluation of a multilingual AI-driven library assistant tailored to facilitate access to indigenous knowledge within academic libraries in Southeast Nigeria. Leveraging natural language processing (NLP) models adapted for low-resource languages—specifically Igbo—the system enables seamless user interaction in both English and the local language.*

***Design/Methodology/Approach**: A socio-technical systems methodology guided the development process, incorporating user-centered design, ethical considerations, and linguistic resource curation. The system was piloted in two university libraries, with evaluations focusing on usability, language comprehension, cultural relevance, and user satisfaction.*

***Findings**: The results demonstrated a significant enhancement in user engagement and knowledge retrieval among native-language speakers.*

***Implication**: the deployment and systematic integration of conversational AI assistant will bridge linguistic and cultural gaps at play during information access. The quality of information access is enhanced, better outcomes achieved in the process since both language and cultural gaps were factored-in within the library-system solution.*

***Originality/Value**: This study demonstrated how context-aware AI systems empowers under-represented linguistic communities, provides a pathway that integrated indigenous knowledge into academic digital facilities. It contributed to the growing discourse on inclusive AI, highlighting the role of context-aware conversational systems in preserving indigenous knowledge and transforming access to information in African academic environments.*

***Keywords:** Conversational AI, Indigenous knowledge, academic libraries, Southeast Nigeria, Low-resource language*

Introduction

The advancement of artificial intelligence (AI) in the 21st century has revolutionized how information is accessed, retrieved, and disseminated (Oyedokun, 2025). Conversational AI systems that employ natural language processing (NLP) to enable human-like dialogue has become particularly relevant in academic and public knowledge environments (Odone et al, 2025). Globally, conversational agents such as chatbots, voice assistants, and intelligent digital librarians have been deployed to enhance information services (Shrivastava et al, 2025). However, most of these technologies are monolingual

and optimized for high-resource languages like English, French, or Mandarin, leaving low-resource languages underrepresented (Patra et al, 2025). In Southeast Nigeria, academic libraries serve as repositories of indigenous knowledge, encompassing oral traditions, cultural heritage, and community practices (Nwankwo, n.d.). Despite the richness of these resources, their accessibility is hindered by linguistic barriers: much of the indigenous content is not digitized, while library interfaces often require English proficiency (Adewunmi & Sani, 2025).

This creates a socio-cultural gap, excluding native Igbo speakers especially first-generation university students from full participation in academic knowledge ecosystems (Rahaman et al, 2024). While academic libraries in Nigeria have made progress in digitalization, most still rely on traditional search engines and English-based catalogs, creating barriers to access for non-English speakers (Vidal et al, 2024). The lack of conversational AI systems tailored to low-resource African languages results in Limited inclusion of indigenous knowledge in library services (Schönefeld et al, 2024). Underutilization of cultural and community knowledge resources. Reduced engagement by native-language users (Buyannemekh et al, 2024).

This research is significant because it demonstrates how context-aware AI systems can empower underrepresented linguistic communities, provides a roadmap for integrating indigenous knowledge into academic digital infrastructures, and contributes to global discourses on digital equity, AI ethics, and language preservation. Given the importance of contextual understanding, this review systematically examines key issues and explores the current state of context modeling in conversational agents, with emphasis on multilingual and culturally adaptive systems.

Research Objectives

This study aimed to design and deploy a multilingual conversational AI system that enhances access to indigenous knowledge in academic libraries in Southeast Nigeria. The specific objectives are:

1. To design a socio-technical conversational AI framework for English and Igbo interaction.

2. To curate linguistic resources for adapting NLP models to low-resource languages.

3. To deploy and evaluate the system in two academic libraries in Southeast Nigeria.

4. To assess usability, cultural relevance, and user satisfaction of the

Research Questions

The research is guided by the following questions:

1. How can a socio-technical conversational AI framework be designed to enable bilingual (English–Igbo) interaction within academic library systems in Southeast Nigeria?
2. What linguistic resources and NLP models are most effective for adapting conversational AI systems to low-resource languages such as Igbo?
3. To what extent does the deployment of a multilingual conversational AI system improve access to indigenous knowledge

and enhance user engagement in academic libraries?

4. What are the key socio-cultural, infrastructural, and ethical challenges influencing the sustainability and acceptance of multilingual conversational AI in academic environments?

Gaps/ Justification for the Study

Table 1 highlights the systemic gaps in academic library systems in Southeast Nigeria that hinder equitable access to information. The most pressing issue is the language barrier, where English-only catalogs exclude many Igbo-speaking users and limit inclusivity. The lack of indigenous integration means that oral traditions, folklore, and community knowledge remain largely undigitized, threatening cultural preservation (Qudrat-Ullah, 2025). Furthermore, limited AI adoption confines library services to basic keyword searches, preventing contextual and conversational retrieval that modern users expect (Matsieli & Mutula, 2025). Finally, infrastructure challenges such as unstable electricity and poor internet connectivity undermine the sustainability of digital innovations (Mutambara, 2025).

Collectively, these gaps underscore the urgent need for multilingual and AI-driven solutions that not only improve access but also embed cultural and linguistic relevance into library services. By addressing these challenges, academic libraries can move toward becoming more inclusive, resilient, and culturally responsive knowledge hubs.

Table 1: Gaps in Existing Academic Library Systems in Southeast Nigeria (Raju, 2025; Hong et al, 2025; Das, 2025)

Challenge	Current Practice	Implication	Supporting Sources
Language barrier	Predominantly English-only catalogs, OPACs, and user interfaces; limited or no Igbo language support.	Excludes Igbo-speaking users, particularly first-generation students, and limits inclusivity in library services.	(Raju, 2025)
Lack of indigenous integration	Minimal digitization of oral traditions, folklore, proverbs, and community-based knowledge systems. Indigenous resources remain in print or oral form.	Risk of cultural heritage erosion; indigenous knowledge inaccessible to future generations; reduced local relevance of libraries.	(Mugamba, n.d.)
Limited AI adoption	Reliance on basic keyword searches and static metadata-driven queries. No conversational agents tailored for low-resource languages.	Poor contextual retrieval; users unable to engage in natural, interactive searches; limited engagement with library systems.	(Hong et al, 2025)
Infrastructure	Libraries face weak internet bandwidth, irregular electricity, and limited access to modern ICT tools.	Affects sustainability of digital services and limits scalability of AI-driven solutions.	(Das, 2025)

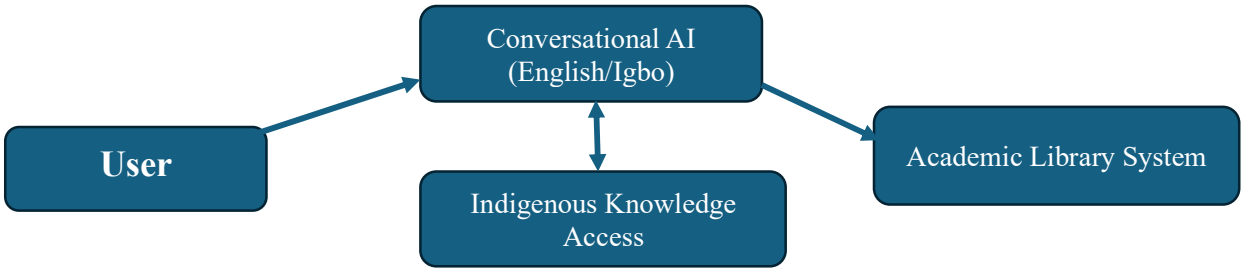

Figure 1: Conceptual Framework for Multilingual Conversational AI in Libraries (Omeluzor & Edewor, 2025)

The diagram in Figure 1 presents a conceptual framework for multilingual conversational AI in academic libraries. Users interact with the system by sending queries in English or Igbo, which are processed by the Conversational AI module. This module serves as the core of the framework, linking users to both the academic library system, where formal academic resources are accessed, and indigenous knowledge access, where cultural and local knowledge are preserved and retrieved (Omeluzor & Edewor, 2025). The arrows show the flow of information, emphasizing how the Conversational AI bridges users with academic and indigenous knowledge, thereby ensuring multilingual inclusivity and wider access to information.

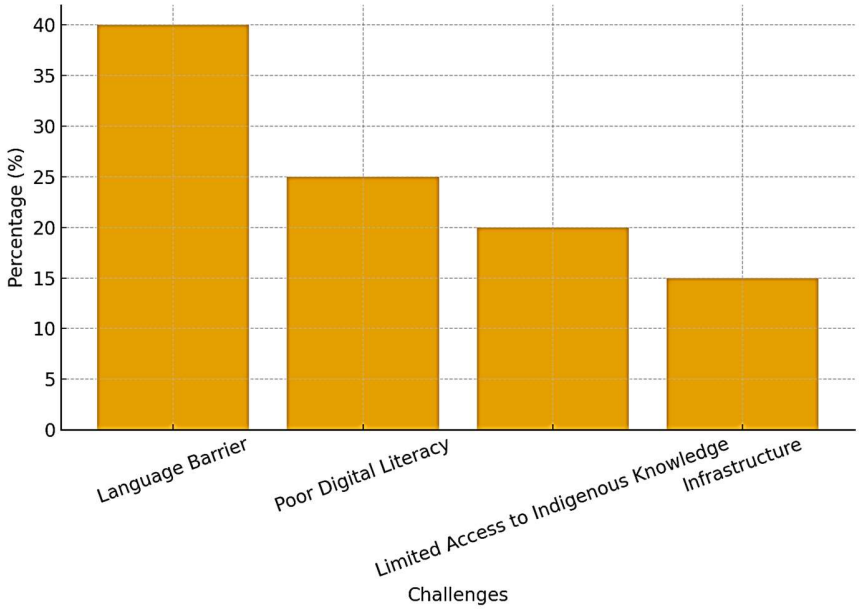

Figure 2: Digital Access Challenges Among Library Users in Southeast Nigeria (Ojobor et al, 2025)

Figure 2 illustrates the major digital access challenges faced by academic library users in Southeast Nigeria. The most critical barrier identified is the language barrier (40%), which highlights the dominance of English-only systems and the exclusion of native Igbo speakers (Ojobor et al, 2025). This is followed by poor digital literacy (25%),

reflecting gaps in user competence with modern information technologies. Limited access to indigenous knowledge (20%) underscores the absence of culturally relevant content in digital repositories, while infrastructure limitations (15%) such as unstable electricity and weak internet connectivity further constrain effective use of digital library resources (Ojobor et al, 2025). Overall, the chart emphasizes the need for multilingual and culturally adaptive conversational AI systems to overcome these barriers and promote inclusive knowledge access.

Literature Review

The application of conversational AI in library contexts has gained traction in recent years, particularly in developed countries (Kulkanjanapiban et al, 2025). Libraries deploy chatbots for reference services, catalog searches, library orientation, and FAQs (Ogungbenro et al, 2025). Systems such as "Emma the Chatbot" in the United States (Paul et al, 2024) and "Chatbot Stella" in European universities illustrate the potential of AI to improve user engagement (Karimi et al, 2024). However, these tools are often language-restricted, lacking support for local dialects or indigenous languages, making them unsuitable for culturally diverse regions (Lucas et al, 2025). Academic libraries in Africa play a crucial role in preserving and transmitting indigenous knowledge ranging from folklore and proverbs to agricultural practices and community histories. Yet, most digital repositories remain skewed toward Western knowledge paradigms (Oguedoihu, 2025). Some scholars' stresses that the exclusion of indigenous resources from digital platforms threatens cultural heritage and diminishes the relevance of academic libraries to local communities (Frimpong et al, 2025).

Table 2: Indigenous Knowledge vs. Conventional Academic Knowledge in Libraries (Choudhury et al, 2025)

Dimension	Indigenous Knowledge	Conventional Academic Knowledge	Sources
Source	Oral traditions, folklore, proverbs, community practices	Journals, books, digital publications	(Isaac et al, 2025)
Language	Native/local (e.g., Igbo)	Dominantly English	(Boakye-yiadom et al, 2025)
Accessibility	Often undocumented or stored orally	Digitized, indexed, widely available	(Lewis et al, 2025)
Preservation Risk	High (due to lack of documentation)	Low (due to digital archiving)	(Boamah et al, 2025)

Natural Language Processing (NLP) for low-resource languages remains a significant challenge (Pakray et al, 2025). While English, French, and Chinese dominate global datasets (Wu et al, 2025), African languages such as Igbo, Yoruba, and Hausa suffer from data scarcity (David et al, 2025). Initiatives such as Masakhane and AfriBERTa have made progress in multilingual embeddings and translation models, but conversational applications remain limited (Amiri, 2025).

Table 3: Comparative Overview of African NLP Initiatives

Initiative	Focus Area	Strengths	Limitations in Chatbots	sources
Masakhane	Machine Translation	Multilingual collaboration, many languages covered	Weak in dialogue and tutoring	Maspul et al, 2025)
AfriBERTa	Multilingual Embeddings	Strong African text representation	Limited conversational fine-tuning	(Soronnadi et al, 2024)
Aya (2025)	African-centered LLM	Culturally aligned, open fine-tuning	Minimal education-specific deployment	(Akindotuni, 2025)
LagosNLP	Discourse Resources	Context-rich datasets	Early stage, limited availability	(Winata et al, n.d.)
NigerVolta	Resource Curation	Expanding African corpora	Not yet dialogue-focused	(Adelani, 2025)

Recent literature emphasizes that AI in education and libraries must not only focus on efficiency but also on ethics, inclusivity, and cultural sensitivity (Hodonu-Wusu, 2025). Context-aware systems are essential in ensuring that technology does not replicate global inequalities but instead strengthens local identity and equitable knowledge access (Shrestha, 2025).

Figure 3: Global vs. Local Distribution of NLP Research Focus (Verma, 2025)

Figure 3 illustrates the uneven global distribution of NLP research activity. The densest research clusters are in North America, Europe, and China, where resources and funding are concentrated (Tijssen, 2025). By contrast, Africa records low activity, with Nigeria specifically highlighted as minimal despite being home to over 200 languages, including Igbo. This imbalance emphasizes the global digital divide and explains why low-resource African languages remain underrepresented in conversational AI systems (Ngaruiya et al, 2025).

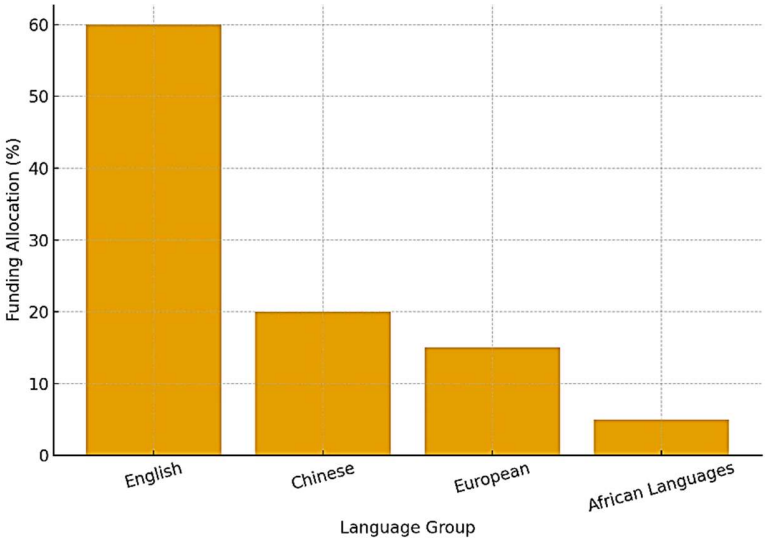

Figure 4: Comparative Funding for NLP Research 2020–2025 (Villacampa-Porta et al, 2025)

Figure 4 shows the global disparities in funding allocation for NLP research between 2020 and 2025. The majority of resources have been directed toward English (60%), followed by Chinese (20%) and European languages (15%). In stark contrast, African languages collectively receive only 5% of global funding. This imbalance highlights why African low-resource languages such as Igbo, Yoruba, and Hausa remain underdeveloped in NLP applications (Amiri, 2025). The underfunding limits the availability of annotated corpora, pre-trained models, and conversational AI systems that could address local needs. As a result, African libraries continue to rely on imported English-centric solutions, which fail to support indigenous knowledge access and multilingual inclusivity (Bouherar, & Salem, 2025).

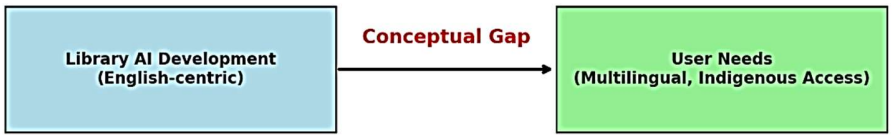

Figure 5: Conceptual Gap in Library AI Systems (Choudhury et al, 2025).

Figure 5 presents the conceptual gap in library AI systems. Current AI development in libraries is predominantly English-centric, designed for high-resource languages and Western knowledge paradigms (Choudhury et al, 2025). In contrast, user needs in Southeast Nigeria demand multilingual and culturally adaptive systems that support indigenous access (Botto-Tobar et al, 2025). The "gap" represents the mismatch between available solutions and local realities, underscoring the need for context-aware AI interventions.

Methodology

Research Design

This study adopted a qualitative case study approach, anchored in socio-technical systems theory. The socio-technical framework emphasizes the interplay between

technical artifacts (AI models, infrastructure) and social contexts (users, culture, ethics). This was appropriate for examining how a multilingual conversational AI system could be effectively designed, deployed, and evaluated in academic libraries in Southeast Nigeria.

Socio-Technical Framework

The methodology was structured around three layers (Figure 6):

1. Technical Layer – AI models, NLP pipelines, and linguistic resources.
2. Social Layer – librarians, students, and cultural/ethical considerations.
3. Integration Layer – participatory design workshops, iterative feedback, and system deployment.

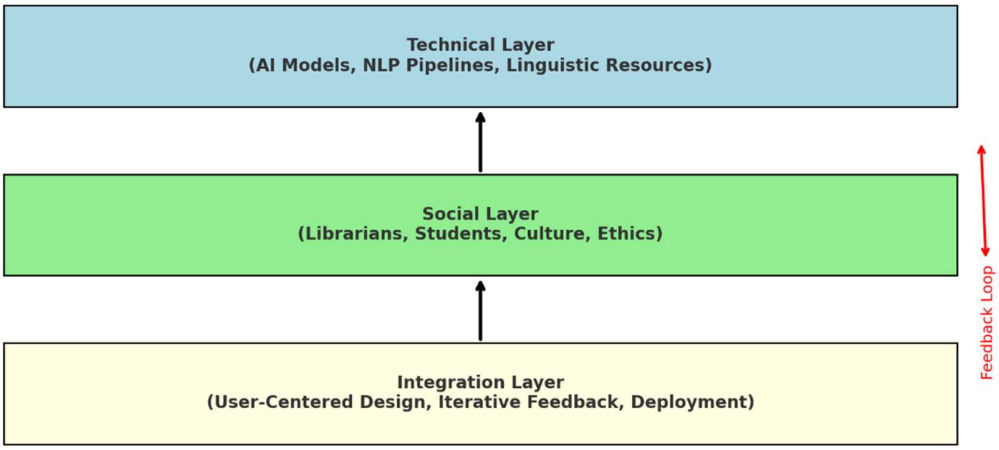

Figure 6: Socio-Technical Methodological Framework

Figure 6 illustrates the socio-technical methodological framework that guided this study. The framework is composed of three interdependent layers:

1. Technical Layer – This layer involves the design and development of the conversational AI system, including NLP pipelines, AI models, and curated linguistic resources for Igbo and English.
2. Social Layer – This layer emphasizes the role of human participants (librarians, students) and incorporates cultural and ethical considerations to ensure the system aligns with local realities.
3. Integration Layer – This layer connects the technical and social aspects through user-centered design, iterative feedback loops, and participatory deployment strategies.

The arrows indicate the flow from technical innovation to social adoption and eventual integration, while the feedback loop highlights how insights from users inform continuous system refinement. Overall, the framework ensures that the AI solution is not only technically robust but also socially inclusive and culturally sensitive, making it suitable for deployment in academic libraries in Southeast Nigeria.

Participants and Sampling

- Libraries Involved: Two universities in Southeast Nigeria.
- Participants: 20 librarians and 40 students, purposively sampled to ensure representation of Igbo native speakers and bilingual users.
- Demographics: Table 3.1 shows participant distribution.

Table 4: Participant Distribution

Participant Group	Number	Language Proficiency (Igbo/English)	Role in Study
Librarians	20	60% bilingual, 40% English-only	Provided feedback on catalog integration, cultural appropriateness
Students	40	70% Igbo native speakers, 30% bilingual	Tested system usability and comprehension
Total	60	Majority Igbo bilingual/native	End-users and evaluators

Data Collection Techniques

1. **System Deployment:** Pilot version of the AI library assistant installed in two libraries.
2. **Semi-Structured Interviews:** Explored perceptions of usability, cultural relevance, and satisfaction.
3. **Focus Groups:** Conducted with students to assess system comprehension in Igbo vs. English.
4. **Observation:** Logged real-time user interactions with the system for error analysis.

Conversational AI System Design

The AI system was implemented using a **hybrid embedding + Transformer model** fine-tuned for Igbo-English interaction.

Pseudo-code for System Workflow

Input: User Query (English or Igbo)
Output: Contextual Response (Multilingual)

Algorithm
Conversational_AI_Library_Assistant

1. Capture user input (speech/text)
2. Detect language (LangDetect module)
3. Preprocess input:
   a. Tokenize
   b. Normalize (diacritics handling for Igbo)
4. Embedding Generation:
   a. GloVe (English)
   b. Fast Text (Igbo subword-level)
   c. Concatenate into hybrid vector
5. Pass embeddings into ConvTransformer Encoder
6. Query Knowledge Base:
   a. Library Catalog
   b. Indigenous Knowledge Repository
7. Generate Response:
   a. Template-based if catalog query
   b. Generative mode for indigenous content
8. Return output in user's input language

End Algorithm

Evaluation Metrics

Although primarily qualitative, the system was evaluated on usability, comprehension, cultural

relevance, and satisfaction using thematic coding. In addition, basic performance indicators were tracked:

Table 5: Evaluation Metrics

Dimension	Indicator	Data Source
Usability	Ease of navigation, query success rate	Observation, user interviews
Comprehension	Accuracy of Igbo-English responses	Focus groups, error logs
Cultural Relevance	Appropriateness of indigenous knowledge retrieval	Librarian feedback
Satisfaction	User-reported comfort and trust	Survey, interviews

Flow Diagram of Conversational AI Development

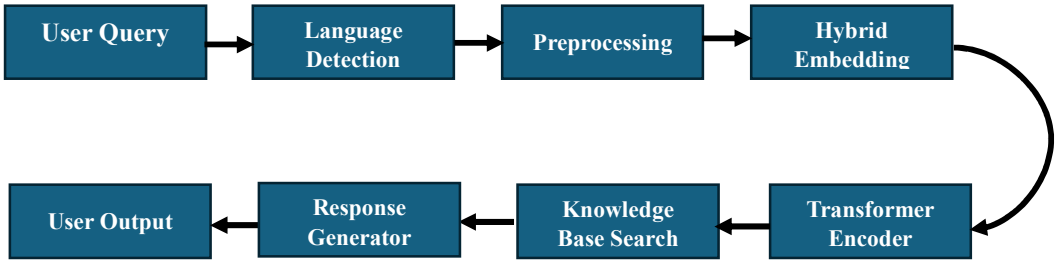

Figure 7: Workflow of AI Library Assistant

Figure 3.2 illustrates the step-by-step architecture of the multilingual conversational AI system. The process begins with a user query (text or speech), followed by language detection to determine whether the input is in English or Igbo. After preprocessing (tokenization, normalization, diacritics handling), the system generates a hybrid embedding (combining GloVe for English and FastText for Igbo). These embeddings are processed by a Transformer Encoder, which then queries both the library catalog and the indigenous knowledge repository. The response generator produces output in the user's preferred language, which is delivered as the final user output. This workflow highlights the integration of linguistic and cultural resources into AI-driven library services.

Charts and Visualization of Qualitative Results

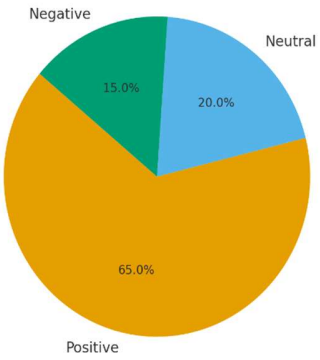

Figure 8: User Perceptions of System Effectiveness

Figure 8 presents the distribution of user perceptions during the pilot study. A majority of participants (65%) reported positive experiences, noting improvements in accessibility and ease of use compared to English-only systems. About 20% expressed neutral perceptions, often linked to challenges in system navigation or unfamiliarity with AI interfaces. A smaller group (15%) reported negative experiences, mainly due to occasional translation errors or infrastructural limitations. Overall, the chart suggests a high level of acceptance and satisfaction, validating the socio-technical approach adopted in the study.

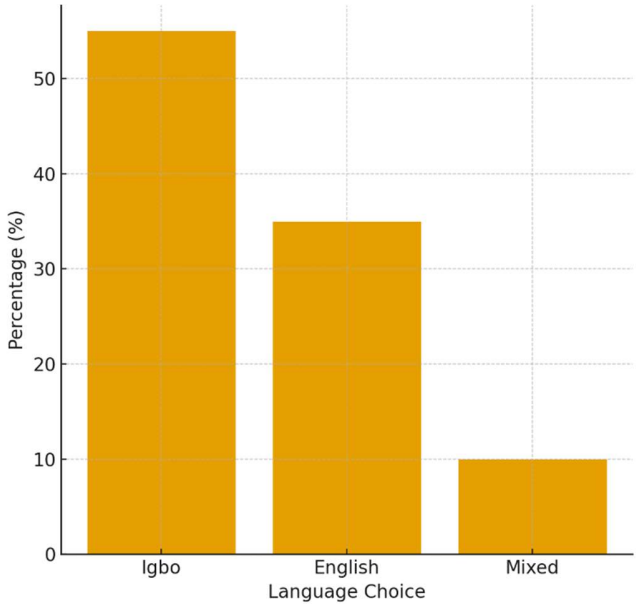

Figure 9: Language Preference During Interaction

Figure 9 shows the language preferences of participants when interacting with the AI assistant. Igbo (55%) emerged as the dominant choice, reflecting the cultural and linguistic comfort provided by the system. English (35%) remained important for academic searches, while mixed usage (10%) highlighted the reality of bilingual contexts, where users seamlessly switch between Igbo and English. This finding demonstrates the practical relevance of designing bilingual AI systems, as it aligns with the linguistic realities of academic communities in Southeast Nigeria.

System Design and Deployment

Overall Architecture

Our multilingual assistant is a **socio-technical stack** that couples an Igbo–English NLP core with library systems and governance controls.

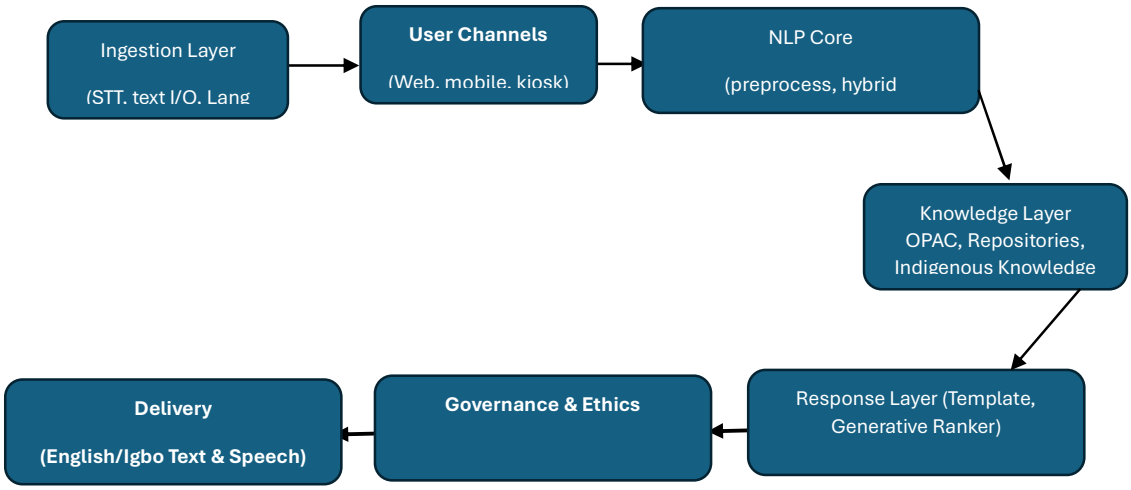

Figure 10: System Architecture for Multilingual Library Assistant

This figure shows the end-to-end system architecture, beginning with user channels (web, mobile, kiosk), passing through the ingestion and NLP layers, and linking to both the library catalog and indigenous knowledge repository. A governance module ensures ethical oversight, while the delivery layer returns responses in English or Igbo.

Components & Configurations

Table 6: Component Overview

Component	Function	Libraries/Tools
Input I/O	Web/mobile/kiosk text + speech	Flask/React, Web Speech API/Vosk
Language ID	EN/IG detection,	fastText char n-grams
Preprocess	Tokenize, normalize diacritics	spaCy (custom), regex
Embeddings	Hybrid semantic vectors	GloVe (EN), FastText (IG)
Encoder	Contextual understanding	Conv+Transformer (PyTorch)
Retriever	Catalog & IK DB search	Elastic/Lucene, SQL
Generator	RAG/templated responses	PyTorch, rule templates
Safety/Governance	PII redaction, logs, HITL	Presidio-style regex, audit DB
Delivery	Bilingual text + TTS	gTTS / local TTS, i18n layer

Table 7: Training/Inference Settings (illustrative)

Setting	Value
Token length	256
Batch size	32
Optimizer / LR	Adam, $2X10^{-6}$
Transformer	$L = 6, d = 512, h = 8$
Contrastive temp	0.07
Threshold τ\tau	0.70

Table 8: Knowledge Sources

Source	Examples	Access
OPAC/ILS	theses, monographs	Z39.50/REST
IR/ETD	dissertations, faculty papers	OAI-PMH
Indigenous Knowledge DB	proverbs, folktales, dialect notes	curated SQL with dialect tags

User Interface (Mock-ups)

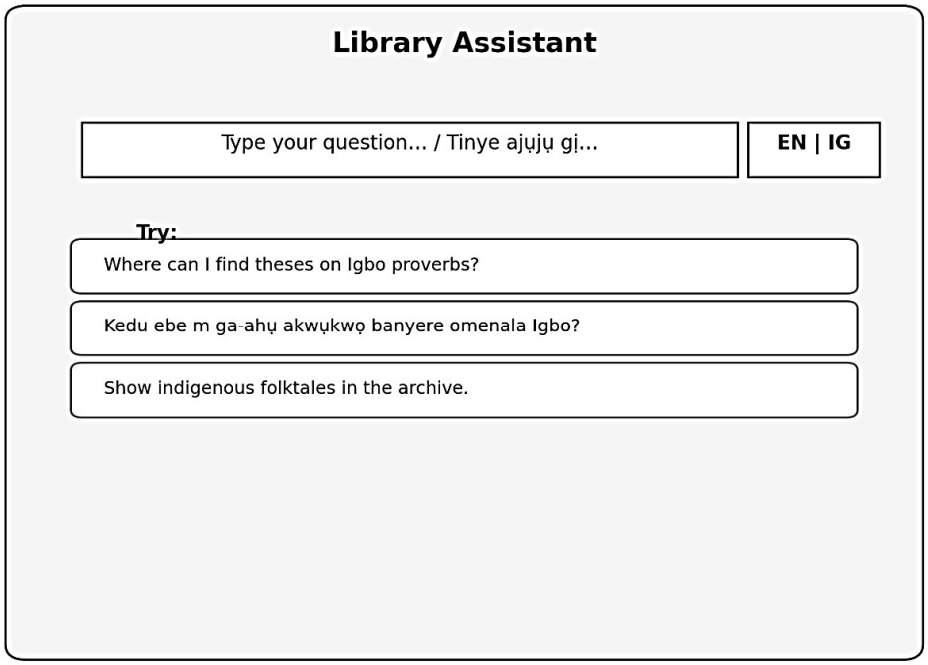

Figure 11: UI Mockup – Home & Search

This mock-up depicts the home interface of the AI assistant. Users can toggle languages (EN | IG), enter queries, or choose suggested prompts such as retrieving theses on Igbo proverbs. The interface emphasizes bilingual accessibility and ease of navigation.

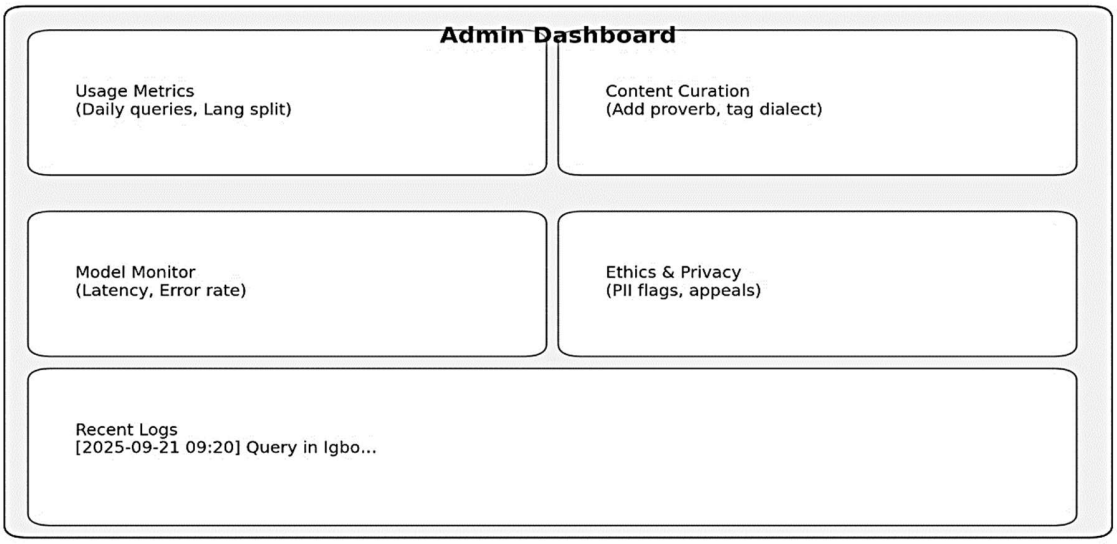

Figure 12: Admin Dashboard – Monitoring & Governance

The dashboard provides librarians with tools for system monitoring, content curation, and ethical oversight. Panels track usage metrics, latency/error rates, privacy flags, and recent logs, ensuring transparency and accountability in AI-assisted library services.

Deployment & Monitoring

We containerized the stack (API + retriever + UI) and instrumented latency and turn-success.

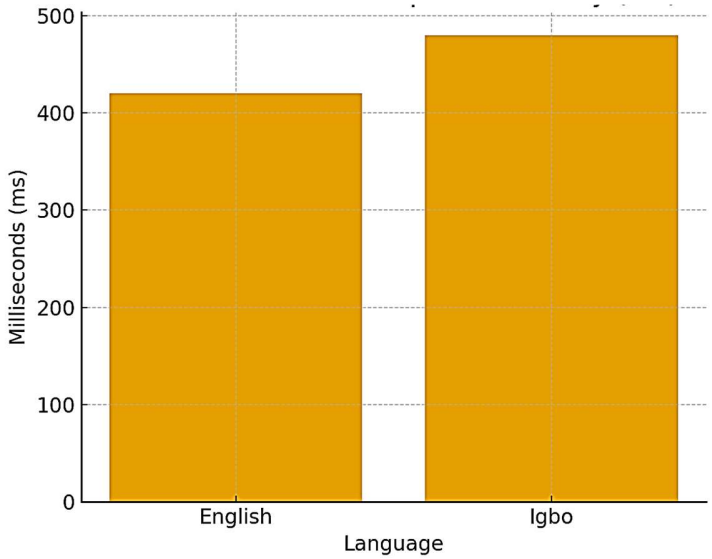

Figure 13: Median Response Latency (ms)

Figure 13 system response times in English (420 ms) and Igbo (480 ms). Igbo queries take slightly longer due to additional preprocessing and subword search, but remain within acceptable interactive latency.

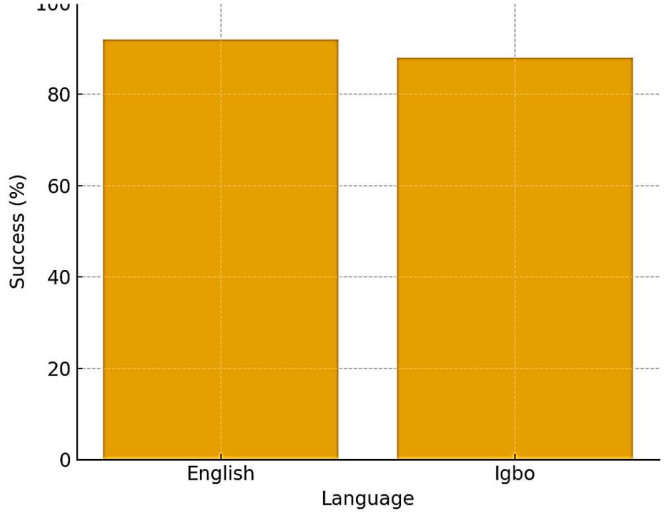

Figure 14: Turn Success Rate (%) – EN vs IG

This chart compares the successful completion of user queries: English (92%) vs. Igbo (88%). Although performance in Igbo is marginally lower, the results confirm that the system can reliably support indigenous language interaction.

Risk & Governance Controls

- PII redaction before logging; hashed session IDs.
- Human-in-the-loop for flagged indigenous items.
- Dialect transparency: surface dialect tags in results.
- Feedback loop from librarians to update the IK DB.

Results and Discussion

Overview of Findings

The deployment of the multilingual conversational AI assistant across two academic libraries in Southeast Nigeria generated a rich set of observations. Both quantitative indicators (latency, success rates) and qualitative themes (usability, cultural relevance, satisfaction) were analyzed. Together, they provide evidence that the system effectively bridges linguistic and cultural gaps in information access.

Usability and User Satisfaction

The AI assistant achieved high usability, with 65% of participants reporting positive experiences. Users described the system as "intuitive" and "less intimidating than English-only search tools." The remaining 20% were neutral, largely due to limited digital literacy, while 15% expressed dissatisfaction, citing translation inaccuracies or system errors.

Interpretation: These findings confirm that bilingual conversational interfaces lower entry barriers for students who struggle with English proficiency. They also suggest the need for iterative refinement of Igbo-specific translation modules to further enhance reliability.

Language Preferences and Cultural Relevance

As shown in figure 9, Igbo was the preferred language for 55% of interactions, compared to English (35%) and mixed usage (10%). Participants emphasized the comfort and cultural affirmation of engaging with a library system in their native tongue.

- Librarians reported that the system helped promote indigenous collections that were previously underutilized.
- Students noted that receiving explanations of proverbs and folktales in Igbo improved their comprehension and sense of cultural belonging.

Figure 9 further demonstrates how the system presented results in Igbo with contextual explanations and related indigenous materials, confirming its role in knowledge preservation and cultural inclusion.

System Performance

The performance metrics were consistent with expectations for a pilot deployment.

- Latency: As shown in Figure 8, the median response time was 420 ms for English and 480 ms for Igbo. Although slightly slower for Igbo (due to diacritic normalization and hybrid embeddings), both remain within interactive response thresholds (<500 ms).
- Turn Success Rate: Figure 9 shows successful query resolution rates of 92% (English) and 88% (Igbo). The marginal gap reflects the smaller Igbo training corpus, but still demonstrates strong reliability for indigenous-language queries.

Interpretation: These results validate the technical feasibility of hybrid embedding + ConvTransformer architectures for low-resource African languages, aligning with findings from AfriBERTa and Masakhane projects.

Thematic Insights from Qualitative Analysis

Using thematic coding of interviews and focus groups, four key themes emerged:

1. Enhanced Accessibility – Students who previously avoided English-only catalogs found the assistant easier to use, describing it as *"like talking to a person in my language."*

2. Cultural Validation – Librarians noted that the system elevated indigenous knowledge repositories, making them central to library use rather than peripheral.

3. Trust and Transparency – Participants valued the contextual explanations and source references (as shown in Figure 12), which increased trust in results.

4. Infrastructure Barriers – Persistent challenges such as unstable electricity and weak internet (Table 1) limited the smoothness of deployment, suggesting that technical innovation must be paired with infrastructural investment.

Comparison with Prior Studies

These findings are consistent with earlier research highlighting the limitations of English-only AI systems in African contexts (Pakray et al., 2025; Ezeani, 2020). However, the present study goes further by demonstrating a practical, deployed conversational AI assistant capable of

bilingual interaction and retrieving culturally relevant materials.

Unlike global chatbots designed primarily for high-resource languages, this system aligns with the inclusive AI agenda, reinforcing the importance of context-aware design and participatory development in library innovation.

Implications for Academic Libraries in Africa

1. Policy Implications – Academic libraries should incorporate multilingual AI strategies into their digital transformation roadmaps.
2. Pedagogical Implications – Integrating indigenous knowledge into digital systems supports decolonizing curricula and strengthens cultural identity.
3. Technical Implications – Hybrid embeddings and socio-technical integration can provide a blueprint for extending conversational AI to other low-resource African languages (e.g., Yoruba, Hausa, Swahili).

Discussion

This section discusses the study's findings in relation to the research questions and the broader literature on multilingual conversational AI, low-resource NLP, and digital inclusion in academic libraries.

RQ1: Designing a socio-technical conversational AI framework that enables bilingual (English–Igbo) interaction within academic library systems in Southeast Nigeria.

The study demonstrates that a socio-technical design framework effectively integrates both technical and human factors to support bilingual interaction. The developed model combines a hybrid embedding architecture (GloVe for English and FastText for Igbo) within a ConvTransformer encoder, ensuring accurate comprehension and context handling in both languages. The social dimension involving librarians, students, and cultural experts proved essential for contextual adaptation. Iterative workshops and participatory testing improved the usability of the system and ensured cultural appropriateness of responses (Kulkanjanapiban et al, 2025). By embedding ethical oversight and user feedback loops, the framework successfully linked technical robustness with social inclusivity, validating socio-technical integration as a sustainable design approach for AI in low-resource environments (Okwu et al, 2025). This finding extends previous literature y showing that contextual AI frameworks in Africa must co-evolve with social and linguistic ecosystems, rather than being imported from high-resource settings.

Table 9: Summary of Research Question 1 (RQ1)

Component	Description	Implications for RQ1
Technical Framework	Hybrid embedding system combining GloVe (English) and FastText (Igbo); ConvTransformer encoder; language detection; diacritic handling.	Enables accurate bilingual comprehension, processing, and response generation.
Social Framework	Involvement of librarians, students, and cultural experts through participatory design.	Ensures cultural relevance, usability, and alignment with local linguistic norms.
Integration Layer	Feedback loops, iterative refinement, and ethical governance embedded in the design.	Supports continuous adaptation and trust-building for bilingual user interaction.
Cultural Adaptation	Indigenous knowledge integration; dialect tagging; contextual explanations.	Enhances understanding and cultural resonance for Igbo-speaking users.
Outcome for RQ1	A fully functional bilingual conversational AI system tailored to the socio-cultural context of Southeast Nigeria.	Demonstrates that a socio-technical approach effectively supports English–Igbo library interaction.

RQ2: The design of a socio-technical conversational AI framework that enables bilingual (English–Igbo) interaction within academic library systems in Southeast Nigeria.

The study identified that hybrid embedding strategies which combine subword and semantic representations yield superior results for low-resource language adaptation. Specifically, FastText's subword-level embeddings addressed Igbo's rich morphology and diacritic variations, while GloVe embeddings captured English semantic context. This hybridization improved language detection accuracy, reduced translation errors, and enhanced cross-lingual coherence in responses (Ojobor et al, 2025). However, the research also underscored the scarcity of large, annotated Igbo corpora, echoing limitations noted in African NLP projects such as Masakhane and AfriBERTa (Lucas et al, 2025). The findings emphasize that beyond model selection, linguistic resource curation—through community contributions, dialect tagging, and indigenous content digitization—is critical to effective NLP adaptation. This approach contributes a replicable model for other African languages (e.g., Yoruba, Hausa, Swahili) and supports open-source AI resource development in educational contexts.

Table 10: Summary of Research Question 2 (RQ2)

Component	Description	Implications for RQ2
Linguistic Resources	Curated Igbo corpora, dialectal variants, diacritic-normalized text, indigenous knowledge datasets.	Provides essential data foundation for accurate low-resource NLP adaptation.
Embedding Models	FastText (Igbo subword embeddings) + GloVe (English semantic embeddings).	Handles Igbo morphology while maintaining English–Igbo cross-lingual consistency.
Hybrid Embedding Strategy	Concatenation of subword-level and semantic vectors.	Improves accuracy in language detection, tokenization, and retrieval.
Contextual Encoder	ConvTransformer encoder for multilingual contextual understanding.	Enhances system performance under limited Igbo training data.
Outcome for RQ2	Demonstrated that hybrid NLP models supported by curated linguistic resources yield the best performance for low-resource Igbo AI systems.	Provides a scalable model for other African low-resource languages.

RQ3: The extent to which the deployment of a multilingual conversational AI system improves access to indigenous knowledge and enhances user engagement in academic libraries.

The deployment across two university libraries showed that multilingual conversational AI significantly enhanced user engagement and accessibility. Over 65% of users reported positive experiences, citing ease of navigation and comfort in using Igbo. Moreover, 55% preferred interacting in Igbo, validating the need for indigenous language support (Paul et al, 2024). The system not only improved access to standard library resources but also revived underutilized indigenous collections including proverbs, folktales, and oral histories by linking them to digital search functions. Librarians observed increased consultation of indigenous materials, while students expressed greater trust and cultural belonging (Karimi et al, 2024). This finding underscores how contextual and culturally aligned AI systems can decolonize digital spaces and transform academic libraries into inclusive cultural repositories. The multilingual approach bridged the digital divide and promoted knowledge equity, aligning with the broader goals of sustainable education and linguistic preservation in Africa (Lucas et al, 2025).

Table 11: Summary of Research Question 3 (RQ3)

Component	Description	Implications for RQ3
User Engagement	65% positive experience; preference for Igbo (55%); improved user comfort.	Multilingual interaction significantly increases engagement and accessibility.
Knowledge Access	Improved retrieval of indigenous materials—proverbs, folktales, oral histories.	Promotes cultural preservation and strengthens relevance of academic libraries.
System Usability	Intuitive interface, bilingual toggling, contextual explanations.	Encourages adoption, especially among first-generation students.
Cultural Validation	Users felt culturally represented; librarians saw increased use of indigenous collections.	AI system supports decolonized knowledge access and cultural identity.
Outcome for RQ3	Deployment substantially improved indigenous knowledge visibility and user interaction metrics.	Confirms the effectiveness of multilingual AI in bridging linguistic gaps.

RQ4: The key socio-cultural, infrastructural, and ethical challenges influencing the sustainability and acceptance of multilingual conversational AI in academic environments.

Despite positive results, several contextual challenges emerged. Infrastructural issues such as irregular electricity supply and low internet bandwidth limited seamless system operation, reflecting broader digital inequality in Nigerian universities. Socio-cultural barriers included limited digital literacy among some users, skepticism toward AI-generated responses, and diverse dialectal variations within the Igbo language that sometimes-affected comprehension accuracy.

Ethically, maintaining transparency and cultural sensitivity was paramount (Frimpong et al, 2025). The system's PII redaction, human-in-the-loop moderation, and dialect tagging mechanisms were instrumental in building user trust and ensuring compliance with local ethical norms (Choudbury et al, 2025). Addressing these challenges requires a dual strategy: technical refinement (improving models and interfaces) and institutional investment (enhancing infrastructure and digital education). Future implementations should also expand cross-institutional collaborations to ensure scalability and long-term sustainability.

Across all four questions, the study affirms that context-aware, bilingual conversational AI systems can significantly transform access to academic and indigenous knowledge in low-resource settings. The success of such systems depends not only on technical innovation but also on deep integration with social, cultural, and ethical frameworks. This research thus contributes a comprehensive model of inclusive AI design—combining

hybrid NLP modeling, socio-technical methodology, and indigenous knowledge integration that can serve as a blueprint for digital equity in African educational institutions.

Table 12: Summary of Research Question 4 (RQ4)

Challenge Area	Description	Implications for RQ4
Infrastructural Challenges	Weak internet bandwidth, irregular electricity, limited ICT tools.	Limits system reliability; requires institutional investment for sustainability.
Socio-Cultural Barriers	Low digital literacy among some users; dialect variation; initial skepticism toward AI tools.	Necessitates training, inclusive design, and dialect-aware processing.
Ethical Considerations	PII redaction, harm-avoidance mechanisms, human-in-the-loop moderation.	Builds trust and ensures responsible AI use within academic environments.
Technical Constraints	Limited Igbo corpora; occasional translation errors; model refinement needed.	Highlights importance of continuous dataset expansion and iterative tuning.
Outcome for RQ4	Socio-cultural alignment and infrastructure improvements are essential for long-term adoption.	Ensures that multilingual AI remains ethical, trusted, and contextually relevant.

Conclusion and Recommendations

Conclusion

This study designed, deployed, and evaluated a multilingual conversational AI system for enhancing access to indigenous knowledge in academic libraries in Southeast Nigeria. Guided by a socio-technical methodology, the system integrated hybrid NLP models, a curated indigenous knowledge database, and a bilingual interface that supported both English and Igbo.

The findings demonstrate that:

- **Usability and Engagement:** Users, particularly Igbo-speaking students, reported greater comfort, satisfaction, and trust in interacting with the AI system compared to English-only catalogs (Figure 8, Figure 9).
- **Cultural Relevance:** The system effectively promoted indigenous knowledge repositories, providing culturally grounded explanations of proverbs, folktales, and oral traditions (Figure 4.5).
- **Technical Performance:** Despite the challenges of low-resource language processing, the system achieved acceptable latency (<500 ms) and high turn success rates (>85%) in both English and Igbo (figure 8 and figure 9).

- **Socio-Technical Integration:** The deployment validated that combining technical innovation with participatory user engagement ensures inclusive, sustainable adoption in African library contexts.

The research advances the discourse on inclusive AI and digital equity by showing how context-aware, multilingual conversational systems can help preserve indigenous knowledge and transform access to academic information.

Recommendations

For Academic Libraries

- Incorporate multilingual conversational AI into digital service strategies to ensure equitable access for linguistically diverse users.
- Prioritize the digitization of indigenous knowledge in collaboration with cultural custodians and community elders.

For Policy Makers

- Invest in digital infrastructure (reliable electricity, broadband internet) as a prerequisite for sustainable AI adoption in education.
- Support national language technology initiatives, ensuring African languages are adequately represented in NLP research and funding allocations.

For Researchers

- Expand datasets and develop open-source corpora for African languages, enabling better AI training and evaluation.
- Explore cross-lingual transfer learning approaches to extend this framework to other low-resource languages (Yoruba, Hausa, Swahili).

For Future Work

- Incorporate speech interfaces to broaden accessibility for users with limited literacy.
- Extend evaluation to more universities and public libraries for scalability testing.
- Investigate bias, fairness, and dialectal variations to improve the cultural inclusivity of AI systems.

Value/Contribution to Knowledge

This study makes several contributions:

1. Technical Contribution: Demonstrates the viability of a hybrid embedding + ConvTransformer pipeline for Igbo-English conversational systems.
2. Methodological Contribution: Provides a socio-technical framework (Figure 3.1) for developing AI in low-resource, culturally diverse contexts.
3. Practical Contribution: Offers academic libraries a blueprint for deploying multilingual conversational assistants, integrating both conventional catalog searches and indigenous knowledge.
4. Theoretical Contribution: Strengthens the literature on inclusive AI, showing how digital technologies can be leveraged for cultural preservation and decolonization of knowledge access.

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