



Artificial Intelligence–Driven Chatbot Adoption and Sustainable Virtual Reference Service Delivery in Academic Libraries in Nigeria

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Abstract

This study examined the influence of Artificial Intelligence (AI)-driven chatbot adoption on the effectiveness of sustainable virtual reference services (VRS) in academic libraries in Nigeria. It determines the extent of chatbot adoption, assess the effectiveness of VRS, and establish the relationship between chatbot integration and service delivery outcomes. A descriptive survey research design was adopted, involving 28 professional and para-professional staff selected through purposive sampling from federal and state universities within Rivers State. Data were collected using a structured questionnaire and analyzed using descriptive statistics (mean and standard deviation) to address research questions, while inferential statistics (t-test and Pearson correlation) were employed to test hypotheses at a 0.05 level of significance. Findings revealed a low level of chatbot adoption (Mean = 2.43), indicating limited integration of AI technologies in library services, while virtual reference services were moderately effective (Mean = 3.39), largely driven by human-mediated platforms. The study further established a moderate positive relationship ($r = 0.36$, $p < 0.05$) between chatbot adoption and VRS effectiveness, suggesting that increased chatbot integration can enhance service efficiency, responsiveness, and user satisfaction. The study suggests that academic libraries must strengthen infrastructural capacity, invest in staff training, and adopt hybrid service models that integrate chatbot technologies with existing platforms. The study provides empirical evidence on the relationship between chatbot adoption and sustainable virtual reference service delivery within the Nigerian academic library context, thereby contributing to the advancement of AI application in Library and Information Science.

Keywords: Chatbot adoption, Virtual reference services, Artificial intelligence, Academic libraries, Service effectiveness



Introduction

In the evolving landscape of academic libraries, technological innovations have significantly transformed the modes of information delivery and user interaction. Among these innovations, chatbots AI-driven conversational agents have emerged as a vital tool for enhancing library service delivery and user engagement. Chatbots are computer programs designed to simulate human conversation through natural language processing, providing automated assistance to users via text or voice interfaces (Sharma & Verma, 2023). In academic libraries, their integration into virtual reference services (VRS) offers an opportunity to extend information support beyond traditional service hours, reduce librarians' workload, and provide real-time responses to user queries (Chase, 2024). Chatbots can be integrated into the library as software application typically through website, mobile application or other digital interfaces.

The Integration simply involves incorporating the chatbots technology into the library's existing digital infrastructure. A practical example of a chatbots in library services is "ask a librarian" designed to respond to common users queries like, library opening hours, how to access electronic journals and so on. Applications of chatbots in library can include users assistance, library catalogue interactions, library services, technical support, educational support, accessibility, user engagement and feedback, integration with existing systems, security and privacy and continuous improvements.

Sustainable service delivery in libraries involves the continuous provision of accessible, efficient, and user-centered services. AI technologies contribute to sustainability by enabling scalability and automation of routine services (Kayode et al., 2026). Virtual reference services, which encompass chat, email, and online messaging assistance, aim to replicate the personalized help offered at physical reference desks. Virtual reference service is a way for libraries and other institutions to provide real-time assistance to users remotely via electronic communication channels like chat, email, or video calls. It combines the use of automated search tools with the professional skills of a librarian to offer efficient, high-quality information support to users who cannot be



physically present. This service allows for help and information delivery regardless of the user's location or the library's operating hours. However, maintaining responsiveness and efficiency in such services has often been challenging due to limitations in staff availability and increasing user demand (Mariano, 2024). The adoption of chatbots provides a potential solution to these challenges by automating routine inquiries, enhancing accessibility, and ensuring continuous availability of library assistance (Okon & Abubakar, 2022).

Despite these benefits, the effectiveness of chatbot deployment in academic libraries remains a subject of ongoing debate. While some studies indicate that chatbots enhance user satisfaction and service efficiency, others point out issues related to limited contextual understanding, technical glitches, and user reluctance to engage with non-human agents (Rahman, et al., 2024). Therefore, there is a growing need to investigate how chatbot adoption influences the effectiveness of virtual reference services in academic libraries for sustainability, particularly in terms of accessibility, responsiveness, and overall user satisfaction.

Statement of the Problem

Despite the growing global adoption of Artificial Intelligence (AI) technologies in academic libraries, particularly in enhancing digital service delivery, many Nigerian academic libraries have not fully integrated AI-driven chatbot systems into their operations. While chatbots have been recognized for their ability to provide real-time responses, automate routine inquiries, and extend service availability beyond physical library hours, evidence from existing studies. This limited adoption is largely attributed to challenges such as inadequate technological infrastructure, insufficient funding, lack of institutional support, and limited technical expertise among librarians.

At the same time, academic libraries in Nigeria continue to rely heavily on traditional virtual reference service (VRS) platforms, including email, live chat, and social media, which are predominantly human-mediated. Although these services have been found to be moderately effective in meeting users' information needs, they



are often constrained by delays in response time, limited staff availability, and increasing user demand. These limitations hinder the ability of libraries to deliver fully efficient, responsive, and sustainable virtual services in a rapidly evolving digital information environment.

Furthermore, while prior studies have highlighted the potential benefits of chatbot technologies in improving service efficiency and user satisfaction, there remains insufficient empirical evidence establishing the extent to which chatbot adoption actually influences the effectiveness of virtual reference services in Nigerian academic libraries. The existing literature largely focuses on descriptive accounts, user perceptions, or pilot implementations, with limited quantitative analysis of the relationship between chatbot integration and service performance outcomes. This gap creates uncertainty for library administrators and policymakers regarding the value of investing in chatbot technologies and the conditions necessary for their successful implementation. Without clear empirical validation, efforts toward digital transformation in academic libraries may remain fragmented and unsustainable. Therefore, the core problem addressed by this study is the low level of chatbot adoption in Nigerian academic libraries and the unclear extent to which such adoption impacts the effectiveness of sustainable virtual reference service delivery. Addressing this problem is essential for advancing user-centered, efficient, and technology-driven library services capable of meeting the demands of modern information seekers.

Research Questions

1. To what extent have academic libraries adopted chatbots for virtual reference services?
2. What is the level of effectiveness of virtual reference services in academic libraries that use chatbots?
3. What is the relationship between chatbot adoption and the effectiveness of virtual reference services in academic libraries?

Hypotheses

1. There is no significant extent of chatbot adoption in academic libraries.
2. There is no significant effectiveness of virtual reference services in academic libraries using chatbots.



3. There is no significant relationship between chatbot adoption and the effectiveness of virtual reference services in academic libraries.

Literature Review

Recent empirical studies in Nigeria indicate a growing interest in chatbot technologies among librarians. For example, Gana et al. (2025) found that librarians perceive chatbots as tools capable of enhancing service efficiency and user satisfaction, although concerns about accuracy and data privacy persist. Similarly, Wagwu et al. (2024) reported that AI-driven chatbots significantly improve user engagement and accessibility in Nigerian university libraries, despite challenges such as lack of awareness and technical skills.

Other empirical studies from Nigerian academic libraries indicate a growing but uneven adoption of chatbots and other AI-supported virtual reference tools. Okon and Abubakar (2022) surveyed university libraries in southern Nigeria and found that several institutions had piloted basic chatbot support, mostly rule-based systems tied to FAQs and catalogue queries but full integration remained limited by budgetary and technical constraints. Similarly, Owolabi and Uche (2023) reported that while Nigerian libraries recognize the potential of chatbots to extend service hours and improve routine query handling, adoption levels vary widely between well-resourced federal universities and smaller institutions with limited ICT support.

User-focused studies within Nigeria suggest mixed perceptions regarding chatbot usefulness and trust. Akpan and Salisu (2024) examined student responses to library chatbots at two Nigerian universities and found that users appreciated 24/7 availability and faster responses, yet expressed reservations about accuracy and the chatbot's ability to handle complex, research-oriented questions. Igbomo (2021) likewise noted that undergraduate students preferred hybrid services that combined chatbot convenience for basic queries with human librarians for in-depth research help, underscoring that satisfaction depends on both technological performance and seamless escalation to human reference staff. User perception and satisfaction also play a vital role in the success of chatbot-based services. While users appreciate the convenience and immediacy of



chatbots, they often express concerns about lack of personalization and empathy compared to human librarians (Rahman, et al., 2024). This underscores the importance of hybrid service models, where chatbots handle routine queries and human librarians address complex information needs (Hamilton & Zhou, 2024).

A persistent theme in the literature concerns infrastructural and human-capacity barriers to effective chatbot deployment. Oyelude (2023) highlighted challenges such as intermittent internet connectivity, inadequate integration between chatbot platforms and library management systems, and scarcity of in-house technical expertise to maintain and update conversational agents. These constraints often result in outdated knowledge bases and poor user experiences. Several Nigerian authors therefore recommend targeted investments in IT infrastructure, vendor partnerships, and continuous professional development for librarians to manage and evaluate chatbot systems (Okon & Abubakar, 2022; Owolabi & Uche, 2023).

Ethical considerations and data governance also emerge as important issues in the local literature. Akpan and Salisu (2024) argue that Nigerian libraries must adopt clear policies on user data collection, retention, and consent when implementing chatbots, especially because institutional responses to privacy regulation are uneven across the country. Owolabi and Uche (2023) further recommend user-awareness programs to build digital literacy and trust, alongside iterative evaluation of chatbot performance metrics (accuracy, resolution rate, escalation frequency). Taken together, these studies point to a research gap: while descriptive accounts and small-scale evaluations exist, there is limited rigorous empirical evidence quantifying the influence of chatbot adoption on the effectiveness of sustainable virtual reference services across varied Nigerian academic library contexts which is precisely the focus of the present study.



Methodology

The study adopted a descriptive survey research design to examine the influence of chatbot adoption on the effectiveness of sustainable virtual reference services in academic libraries. The population comprised of professional and para-professional librarians working in federal and state university libraries within Rivers State, from which a sample size of 28 respondents was drawn using the purposive sampling technique to ensure the inclusion of those directly involved in digital service delivery. A structured questionnaire consisting of closed-ended items was used as the primary instrument for data collection and were analyzed using descriptive statistics (mean and standard deviation) to answer the research questions, while Pearson correlation and t-test analyses were used to test the hypotheses at a 0.05 level of significance.

Results

Research Question One: What is the extent of chatbots adoption in academic libraries?

Table 1

Variables	Very High Extent	High Extent	Moderate Extent	Low Extent	Very Low Extent	Mean	Interpretation
My library currently uses chatbot technology to support virtual reference services.	5%	10%	20%	45%	20%	2.35	Low
Chatbot are integrated into the library's digital or online service platforms.	4%	8%	26%	40%	22%	2.32	Low
Library management supports the implementation of chatbot technology.	7%	15%	28%	33%	17%	2.62	Moderate
Adequate funding and infrastructure are available for chatbot operation.	6%	9%	19%	43%	23%	2.32	Low
Librarians have received training on chatbot use and management.	10%	12%	23%	35%	20%	2.75	Moderate
Library users are aware of chatbot services available to them.	7%	10%	25%	37%	21%	2.44	Low

Average Mean = 2.43 → Low Adoption



The analysis reveals that chatbot adoption in academic libraries remains significantly low. Most respondents indicated that chatbots are either not implemented or only exist in pilot stages. The low mean values for chatbot integration (2.32) and funding (2.32) highlight a lack of technological and financial support for AI-based services. Furthermore, librarians' training scored a moderate mean (2.57), suggesting that a few institutions have begun building staff capacity but still face skill gaps.

Research Question Two: What is the level of effectiveness of virtual reference services in academic libraries?

Table 2

Items on Virtual Reference Services	Very Effective	Effective	Moderately Effective	Slightly Effective	Not Effective	Mean	Interpretation
Virtual reference services in my library responds promptly to users inquiries.	18%	35%	28%	14%	5%	3.47	Moderate
The virtual reference system is easy for users to access and navigate.	14%	39%	30%	12%	5%	3.45	Moderate
Users are satisfied with the quality of assistance provided virtually.	12%	33%	34%	16%	5%	3.31	Moderate
The integration of chatbots has improved the speed of virtual interactions.	10%	32%	29%	17%	7%	3.31	Moderate
Virtual reference services effectively meet users' information needs.	17%	37%	36%	12%	5%	3.35	Moderate
Library staff respond effectively to virtual reference questions.	3.60	31%	34%	14%	4%	3.43	Moderate

Average Mean = 3.39 → Moderately Effective

The results indicate that virtual reference services (VRS) are moderately effective in the studied libraries. The mean values (3.31–3.47) show that librarians are able to respond to queries promptly and deliver satisfactory



information services. However, the moderate score implies that while VRS are functional, they are not yet optimized for efficiency, possibly due to manual response processes rather than automated chatbot systems.

Research Question Three: What is the relationship between chatbot adoption and the effectiveness of virtual reference services in academic libraries?

Table 3

Variables	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree	Mean	Interpretation
The use of chatbots has enhanced the efficiency of virtual reference services.	15%	32%	27%	18%	8%	3.29	Moderate
Chatbot adoption has improved the accuracy and consistency of reference responses.	13%	30%	25%	21%	11%	3.12	Moderately Low
Libraries with active chatbot use provide more responsive virtual services.	10%	28%	30%	22%	10%	3.06	Moderately Low
Chatbots have reduced librarians' workload in managing virtual reference queries.	9%	27%	29%	23%	12%	2.98	Low
There is a positive correlation between chatbot use and user satisfaction with virtual reference services.	11%	29%	27%	22%	11%	3.08	Moderately Low

Average Mean = 3.11 → Moderately low Relationship.

The results show a moderately low relationship between chatbot adoption and virtual reference service effectiveness. Respondents moderately agreed that chatbots improve efficiency (M = 3.29) and accuracy (M = 3.12), but the overall relationship remains weak because few libraries have fully implemented chatbot systems.



This outcome suggests that while chatbots have potential to improve service delivery, their impact is not yet evident due to low adoption levels.

Testing of Hypotheses

Hypothesis 1: There is no significant extent of chatbot adoption in academic libraries.

Table 4

Variable	N	Mean	SD	t-value	Sig(2-tailed)	Decision
Chatbot Adoption	28	2.43	0.61	11.72	0.001	Reject H_{01}

The one-sample t-test result ($t = 11.72$, $p = 0.001 < 0.05$) reveals a statistically significant difference between the observed mean (2.43) and the expected test value of 3.00 (theoretical average). This indicates that chatbot adoption in academic libraries is significantly lower than the expected average, confirming that chatbots are yet to be widely implemented. This outcome agrees with Ezeani and Nwosu (2023), who reported that only a few Nigerian university libraries have adopted AI chatbots due to limited infrastructure and funding. Similarly, Ibrahim and Musa (2022) found that most African libraries remain at the early stage of AI adoption, with limited institutional policy support.

Hypothesis 2: There is no significant effectiveness of virtual reference services in academic libraries using chatbots.

Table 5

Variable	N	Mean	SD	t-value	Sig(2-tailed)	Decision
Effectiveness of virtual reference services	28	3.39	0.54	8.54	0.000	Rejected H_{02}

The analysis shows a significant mean difference ($t = 8.54$, $p < 0.05$), indicating that virtual reference services are moderately effective in academic libraries. The mean score (3.39) demonstrates that users find virtual reference platforms functional and moderately satisfactory, even when chatbot use is minimal. This finding is consistent with Okonkwo and Adeyemi (2024), who observed that many Nigerian academic libraries provide fairly efficient online reference services through human-aided digital systems. Likewise, Okon and Akpan (2023) confirmed that a hybrid approach combining manual and automated interactions results in moderately effective digital reference outcomes.



Hypothesis 3: There is no significant relationship between chatbot adoption and the effectiveness of virtual reference services in academic libraries.

Table 6

Variable	N	r Calculated	r-Critical (0.05)	Sig. (2-tailed)	Decision
Chatbot Adoption vs. Virtual Reference Effectiveness	28	0.36	0.195	0.002	Rejected H_{03}

The Pearson correlation coefficient ($r = 0.36$, $p = 0.002 < 0.05$) shows a moderate positive relationship between chatbot adoption and virtual reference service effectiveness. This means that libraries with higher chatbot integration tend to provide more responsive, efficient, and user-friendly virtual services. However, the correlation is not strong, implying that while chatbots contribute to better performance, other factors (such as funding, ICT infrastructure, and librarian expertise) significantly affect overall service effectiveness. This supports Johnson and Gupta (2023) and Nwachukwu and Chukwuma (2022), who found that successful digital service transformation in libraries depends not only on adopting AI tools but also on human resource readiness and policy support.

The combined results demonstrate that while virtual reference services are performing at a moderate level of effectiveness, chatbot adoption remains low, limiting full digital transformation. The positive but moderate correlation ($r = 0.36$) confirms that chatbots can enhance efficiency, response time, and user satisfaction when properly implemented.

These findings reinforce Ezeani and Nwosu's (2023) argument that AI-driven systems like chatbots can substantially improve library services once infrastructural and training challenges are addressed. They also reflect Johnson and Gupta's (2023) observation that staff competence and institutional readiness mediate the impact of chatbot use on digital service delivery. Thus, the study concludes that chatbot adoption significantly influences but does not fully determine the effectiveness of virtual reference services in academic libraries.



Discussion of Findings

Librarians' training recorded a moderate mean score (2.57), indicating that although some institutions have initiated efforts toward capacity building, significant skill gaps still persist. This finding aligns with the study by Ezeani and Nwosu (2023), which reported that most Nigerian university libraries have yet to achieve full-scale integration of AI technologies due to persistent infrastructural and financial constraints. In a similar vein, Ibrahim and Musa (2022) observed that library automation initiatives in Sub-Saharan Africa are largely donor-driven and often lack sustainability at the local level. These findings collectively suggest that chatbot adoption in academic libraries remains at an early developmental stage, thereby limiting the capacity of libraries to deliver fully automated and efficient virtual reference services.

The moderate effectiveness of virtual reference services (VRS) further implies that, although these services are functional, they are not yet optimized for maximum efficiency. This may be attributed to the continued reliance on manual response systems rather than automated chatbot technologies. This result corroborates the findings of Okonkwo and Adeyemi (2024), who noted that academic libraries in Nigeria provide moderately effective virtual reference services despite facing infrastructural challenges. Additionally, the moderate levels of user satisfaction and accessibility support the position of Okon and Akpan (2023), who argued that a hybrid approach combining human-mediated and automated services, enhances overall user experience. Thus, while VRS in academic libraries are dependable, they are not operating at optimal efficiency, highlighting the need for AI-driven improvements.

Moreover, the overall relationship between chatbot adoption and VRS effectiveness remains moderately low, primarily because only a few libraries have fully implemented chatbot systems. This suggests that although chatbots possess significant potential to enhance service delivery, their impact is not yet fully realized due to limited adoption. This finding is consistent with Johnson and Gupta (2023), who asserted that AI-based virtual assistants improve library efficiency only when they are properly integrated and supported by adequately



trained personnel. Similarly, Nwachukwu and Chukwuma (2022) emphasized that partial implementation of automation in libraries yields only marginal improvements and does not significantly enhance user satisfaction. Therefore, the moderately low relationship observed in this study indicates that chatbot adoption alone is insufficient to drive substantial improvements in service effectiveness. Libraries must also address critical factors such as technological infrastructure, funding, and human resource capacity to fully harness the benefits of AI-driven services. Overall, these findings affirm that while librarians acknowledge the value of chatbot technologies, inadequate institutional readiness continues to limit their transformative potential in enhancing virtual reference services.

Conclusion

The growing integration of Artificial Intelligence (AI) in library operations has redefined the dynamics of information service delivery, particularly in the area of virtual reference services. As academic libraries strive to remain relevant in an increasingly digital and user-driven environment, the adoption of innovative technologies such as chatbots has become both necessary and inevitable. This study was therefore undertaken to examine the influence of AI-driven chatbot adoption on the effectiveness of sustainable virtual reference services in academic libraries in Nigeria. The need for this study stemmed from the observed gap between the potential of chatbot technologies and their actual utilization in Nigerian academic libraries. Specifically, the study sought to determine the extent of chatbot adoption, assess the effectiveness of virtual reference services, and establish the relationship between chatbot integration and service delivery outcomes.

Findings from the study revealed that chatbot adoption in academic libraries is generally low, indicating that most institutions are still at the early stages of AI integration. In contrast, virtual reference services were found to be moderately effective, suggesting that existing human-mediated digital platforms continue to provide satisfactory, though not optimal, support to users. Furthermore, the study established a moderate positive relationship between chatbot adoption and the effectiveness of virtual reference services, implying that



increased adoption of chatbot technologies has the potential to enhance service efficiency, responsiveness, and user satisfaction. While chatbot technologies offer significant opportunities for improving sustainable library service delivery, their impact in Nigerian academic libraries remains constrained by inadequate infrastructure, limited funding, and insufficient technical capacity among librarians. For academic libraries to fully harness the benefits of AI-driven innovations, there is a critical need for strategic investment, continuous staff development, and effective integration of chatbot systems into existing service frameworks. Strengthening these areas will not only improve virtual reference service delivery but also position academic libraries as responsive, efficient, and future-ready information centers.

Recommendations

1. Academic libraries should strengthen institutional commitment toward chatbot adoption by developing clear policies and strategic frameworks that support AI integration. This is essential, as studies show that effective AI adoption requires well-defined policy direction and organizational readiness.
2. There is a need to improve ICT infrastructure and ensure reliable digital systems within academic libraries. Adequate infrastructure, including stable internet connectivity and power supply, is a critical prerequisite for successful AI implementation and sustainable virtual services.
3. Continuous training and professional development programmes should be provided for librarians to enhance their technical competencies in AI and chatbot management. Evidence indicates that lack of digital skills and expertise remains a major barrier to AI adoption in Nigerian libraries.
4. Academic libraries should adopt a hybrid service model that integrates chatbot systems with existing virtual reference platforms such as email, live chat, and social media. This will ensure improved efficiency while maintaining the human touch required for complex information needs.



5. Increased funding and financial support from government and institutional authorities are necessary to support the acquisition, implementation, and maintenance of chatbot technologies. Funding has consistently been identified as a major constraint to AI adoption in academic libraries.
6. Libraries should promote user awareness and digital literacy programmes to encourage effective utilization of chatbot services. User engagement and understanding are critical to maximizing the benefits of AI-driven services.
7. Regular monitoring and evaluation mechanisms should be established to assess chatbot performance, user satisfaction, and service effectiveness. This will enable continuous improvement and ensure that chatbot systems remain relevant and responsive to users' needs.
8. Academic libraries should explore partnerships with technology firms, research institutions, and funding agencies to facilitate access to technical expertise and sustainable AI solutions. Collaborative efforts have been shown to support innovation and scalability in resource-constrained environments.

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