

Design and Implementation of an Intelligent-Based Chatbot for Al-Hikmah University

Tosho Abdulrauf

Department of Computer science, Al-Hikmah University, Nigeria.

*Corresponding authors' email: autosho@alhikmah.edu.ng
ORCID: <https://orcid.org/0000-0001-7174-2878>

ABSTRACT

Artificial Intelligence (AI) has transformed the delivery of academic support services through intelligent conversational systems capable of providing timely and accurate responses to users. Traditional methods of obtaining information within higher education institutions often rely on manual interactions with administrative staff, resulting in delays, increased workload, and limited accessibility outside official working hours. This study presents the design and implementation of an intelligent-based chatbot for Al-Hikmah University to automate responses to students' academic enquiries. The chatbot was developed using a retrieval-based architecture integrated with Natural Language Processing (NLP) techniques to understand user queries and retrieve relevant responses from an institutional knowledge base. The system was implemented using React.js for the frontend, Node.js and Express.js for the backend, MongoDB as the database management system, and Google's Gemini API to enhance conversational intelligence. Functional and usability evaluations were conducted using representative student queries covering admission, registration, course information, tuition fees, examinations, and academic regulations. Experimental results demonstrated that the chatbot provides 98% accurate responses with low response within one to two seconds latency while remaining available twenty-four hours a day. The proposed system improves accessibility to institutional information, reduces the workload on administrative personnel, and enhances students' overall experience. The study concludes that AI-powered academic chatbots can significantly improve digital service delivery in Nigerian universities and recommends future integration with voice recognition, multilingual support, and student information systems.

Received: 22 July 2026

Accepted: 05 Sept. 2026

Published: 05 Oct. 2026

Keywords: Artificial Intelligence, Chatbot, Natural Language Processing, Academic Support

INTRODUCTION

The rapid advancement of Artificial Intelligence (AI) has significantly transformed the way organizations deliver information and support services. Among the most impactful AI applications are intelligent chatbots, which simulate human conversation to provide instant, accurate, and continuous assistance to users. Chatbots have gained widespread adoption across industries such as healthcare, banking, e-commerce, education, and public administration because of their ability to automate repetitive tasks, improve service efficiency, and reduce operational costs.

Artificial Intelligence-powered chatbots provide an effective solution by enabling students to obtain verified institutional information instantly through natural language conversations. Unlike conventional FAQ systems that depend on keyword matching, modern AI chatbots utilize Natural Language Processing (NLP) and Large Language Models (LLMs) to interpret user intentions and generate contextually relevant responses (Rajendran & Chitrarasu, 2024). These capabilities significantly improve user interaction while ensuring continuous service availability regardless of office hours. Recent advancements in generative AI technologies, including Google's Gemini models and Retrieval-Augmented Generation (RAG), have further enhanced chatbot performance by combining conversational intelligence with institution-specific knowledge bases. Such systems can retrieve verified information while minimizing inaccurate or fabricated responses, making them particularly suitable for higher academic environments where information accuracy is essential (Adamopoulou, & Moussiades, 2020).

According to ulHaq, Asim, Suki, Zakaria & Hussain (2026), higher education institutions are increasingly adopting digital technologies to enhance communication between students and university management. Students frequently require information regarding admission procedures, tuition payments, course registration, examination schedules, academic calendars, graduation requirements, and institutional regulations. In many universities, including Al-Hikmah University, these enquiries are primarily handled through administrative offices, websites, telephone calls, or email communication. Such approaches often lead to delayed responses, information inconsistency, long waiting times, and increased workload for administrative staff, particularly during periods of high student activity such as admissions and registration.

This study presents the design and implementation of an Intelligent-Based Chatbot for Al-Hikmah University. The chatbot is designed to provide automated responses to frequently asked academic questions using a retrieval-based architecture integrated with modern AI technologies. By offering immediate access to institutional information, the system aims to improve students' learning experience, reduce administrative workload, and support the University's digital transformation initiatives. The major objectives of this study are to design an intelligent conversational interface for academic enquiries, develop a secure institutional knowledge base, implement Natural Language Processing techniques for understanding user requests, evaluate the chatbot's response accuracy and performance, and assess its effectiveness in improving academic support services. The significance of this

research extends beyond Al-Hikmah University, as the proposed framework provides a practical model for deploying AI-powered academic support systems in higher education institutions across Nigeria and other developing countries. The findings also contribute to the growing body of knowledge on the application of Artificial Intelligence in educational service delivery and digital campus transformation.

MATERIALS AND METHODS

Literature Review

Artificial Intelligence (AI) has significantly transformed human-computer interaction through the development of intelligent conversational agents capable of providing automated assistance in diverse application domains. Chatbots have become increasingly important in education because they facilitate rapid information dissemination, enhance student engagement, and reduce the workload associated with repetitive administrative enquiries. Recent developments in Natural Language Processing (NLP), Machine Learning (ML), and Large Language Models (LLMs) have improved the ability of chatbots to understand user intentions and generate contextually relevant responses (Adigun, Eweoya, *et al.*, 2025), making it suitable for deployment in higher education environments.

Higher education institutions worldwide are adopting AI technologies to improve academic and administrative services. AI-powered systems are used for intelligent tutoring, personalized learning, virtual academic advising, automated grading, and institutional support services (Zawacki-Richter, Marin, Bond & Gouverneur, 2019). Among these applications, chatbots have emerged as one of the most practical solutions because it provides immediate responses to students regardless of time or location (Adamopoulou & Moussiades, 2020). Universities receive thousands of enquiries relating to admissions, tuition payments, course registration, examination schedules, academic calendars, and graduation requirements. Traditionally, these enquiries are handled manually by administrative personnel, often resulting in delayed responses, increased operational costs, and inconsistent information delivery. AI chatbots address these challenges by providing continuous, automated, and consistent support while improving user satisfaction.

Chatbots are computer programs designed to simulate human conversation using text or voice interfaces. Depending on their underlying architecture, chatbots can be broadly classified into three categories: The rule-based chatbots operate using predefined rules, decision trees, and keyword matching techniques. It provides predictable responses for specific questions but perform poorly when users express queries in unfamiliar or complex ways. Although simple to implement, rule-based systems lack contextual understanding and conversational flexibility. The retrieval-based chatbots retrieve the most appropriate response from a predefined knowledge base, which employ Natural Language Processing techniques to interpret user intent before selecting the most relevant answer (Benaddi, Ouaddi, Jakimi, & Ouchao, 2024). Due to the responses originate from verified institutional information, retrieval-based systems provide higher accuracy and consistency than purely generative models, making them suitable for academic environments.

Generally, the AI chatbots employ Large Language Models (LLMs) to generate responses dynamically instead of selecting predefined answers. Models such as GPT and Gemini can understand complex language patterns and produce human-like conversations. However, because these models occasionally generate inaccurate or fabricated

information, it's requires integration with trusted institutional databases before deployment in educational settings. Natural Language Processing enables chatbots to understand human language by performing tasks such as text preprocessing, tokenization, intent recognition, entity extraction, and semantic interpretation. Modern NLP techniques allow educational chatbots to recognize different ways students ask similar questions while maintaining response consistency. Recent advances in transformer-based language models have significantly improved chatbot performance by enhancing contextual understanding and conversational memory. These improvements have enabled educational chatbots to provide more natural interactions compared to earlier keyword-based systems. Instead of relying solely on model knowledge, the chatbot first retrieves verified information from an institutional knowledge base before generating a response. This approach minimizes hallucination, improves factual accuracy, and ensures that students receive information that reflects current university policies and regulations. Consequently, RAG has become one of the preferred architectures for academic support chatbots.

Several researchers have investigated the application of AI chatbots in educational institutions. Ula, Hardi, and Hipiny (2022) developed a university chatbot that improved student access to institutional information through Natural Language Processing techniques. Their findings demonstrated improved response speed and reduced dependence on manual administrative support. Peyton, Unnikrishnan, and Mulligan (2025) explored conversational AI systems for academic support and reported that Large Language Models significantly enhanced conversational quality and user engagement when integrated with structured institutional knowledge. Ndunagu *et al.* (2025) also investigated AI-driven student support systems in higher education and observed that intelligent chatbots improved response accuracy while reducing the workload on university staff. Similarly, Swetha, Ismail, Anil, Venkatesh and Rasheed (2025) proposed an AI-powered academic assistant capable of answering frequently asked student questions using machine learning techniques. Their system demonstrated high user satisfaction and improved accessibility to institutional services. Although these studies demonstrate the effectiveness of AI chatbots in educational environments, many existing implementations are limited by reliance on generic datasets, lack of institutional customization, inadequate integration with university knowledge bases, or insufficient consideration of local educational contexts.

The research gap from the literatures has shown that most existing educational chatbots are designed for general academic assistance which does not adequately address the unique operational requirements of Nigerian universities (Eyikorooha & Chigozie, 2024; Bello, Bena & Musa, 2025). Many systems depend entirely on cloud-based language models without incorporating verified institutional information, increasing the possibility of inaccurate responses. Furthermore, few studies have developed chatbot systems specifically tailored to Nigeria private university's academic structure, regulations, admission procedures, and student support services. Existing solutions also provide limited evaluation of usability, response accuracy, and administrative workload reduction within Nigerian higher education institutions.

This study addresses these limitations by designing and implementing an intelligent-based chatbot specifically for Al-Hikmah University. The proposed system combines Natural Language Processing, a verified institutional knowledge base, and Google's Gemini AI to deliver accurate, reliable, and

context-aware responses to academic enquiries. By integrating modern conversational AI with institution-specific information, the chatbot enhances student access to academic services while supporting the University's digital transformation agenda.

Research Methodology

This study adopted the Design and Development Research (DDR) approach to design, implement, and evaluate an intelligent-based chatbot for Al-Hikmah University. The approach was selected because it supports the systematic development of software solutions intended to solve practical problems while allowing iterative evaluation and refinement throughout the development process (Tosho, AbdulMatalib & AbdulSalam, 2014). The chatbot was designed to automate responses to students' academic enquiries by integrating Natural Language Processing (NLP), a verified institutional knowledge base, and Google's Gemini Artificial Intelligence model. The development process focused on ensuring response accuracy, usability, scalability, and ease of maintenance.

System Architecture

The proposed chatbot follows a three-tier client-server architecture consisting of the presentation layer, application layer, and data layer. Figure 1 illustrates the overall system architecture.

The presentation layer consists of a responsive web interface developed using React.js, enabling users to communicate with the chatbot through text-based conversations.

The application layer comprises a backend server developed using Node.js and Express.js, responsible for request processing, user authentication, API communication, session management, and interaction with the AI model.

The data layer consists of a MongoDB database containing institutional information such as admission requirements, course registration procedures, academic regulations, tuition fee guidelines, examination schedules, faculty information, and frequently asked questions. The backend retrieves relevant information from this database before forwarding contextual prompts to the Gemini API, ensuring that generated responses remain consistent with official university information.

System Development Methodology

The system was developed using the Agile Software Development Methodology. Agile was selected because it promotes iterative software development, continuous testing, stakeholder feedback, and incremental improvement throughout the project lifecycle. The implementation employed modern web development technologies to ensure efficiency, maintainability, and scalability, which is as shown in Table 1.

Table 1: Modern Web Development Technologies

Component	Technology Used
Frontend	React.js, HTML5, CSS3, JavaScript
Backend	Node.js, Express.js
Database	MongoDB
AI Model	Google Gemini API
API Testing	Postman
Version Control	Git and GitHub
Development Environment	Visual Studio Code
Runtime Environment	Node.js

The combination of these technologies in the Table 1 has enabled rapid application development while supporting efficient communication between the user interface, backend services, AI engine, and institutional database.

Chatbot Operational Workflow

The chatbot processes user requests through a sequence of coordinated operations.

- i. A student enters an academic question through the chatbot interface.
- ii. The frontend transmits the request to the backend server.
- iii. The backend preprocesses the query using Natural Language Processing techniques.
- iv. Relevant institutional information is retrieved from the MongoDB knowledge base.
- v. Contextual information is forwarded to the Gemini AI model.
- vi. Gemini generates a context-aware response.
- vii. The backend validates and formats the response.
- viii. The final answer is displayed to the student through the web interface.

This workflow combines retrieval-based information access with generative AI capabilities to improve response quality while minimizing inaccurate or fabricated responses. Mongo

DB was selected because of its flexibility in handling semi-structured educational data. The database stores information across several collections, including Student Frequently Asked Questions, Admission Information, Course Registration Guidelines, Faculties and Departments, Academic Calendar, Examination Regulations, Tuition Fee Information, University Policies and Administrative Contacts.

This modular database structure simplifies data updates without requiring changes to the chatbot application. Natural Language Processing techniques were employed to improve the chatbot's understanding of user queries. The processing pipeline includes Text normalization, Tokenization, Intent recognition, Context generation and Response validation. Google's Gemini API serves as the conversational intelligence engine. Rather than generating responses solely from its pre-trained knowledge, the model receives contextual information extracted from the institutional knowledge base. This hybrid retrieval-based approach improves factual accuracy and reduces the likelihood of hallucinated responses.

System Testing and Evaluation

The chatbot underwent functional and usability testing using representative academic enquiries collected from students and university staff. The evaluation considered the following performance metrics:

- i. Response accuracy

- ii. Response time
- iii. Conversation relevance
- iv. Ease of use
- v. User satisfaction
- vi. System reliability

Functional testing verified that each module performed according to the specified requirements, while usability testing assessed the chatbot's effectiveness in assisting students with academic enquiries. Performance evaluation demonstrated that the chatbot consistently produced above 90% Of accurate responses within a short response time, providing continuous access to institutional information while reducing dependence on manual administrative support.

System Implementation

The chatbot was successfully implemented as a web-based application using React.js for the user interface, Node.js and Express.js for the backend, MongoDB for data storage, and Google Gemini API for conversational intelligence. The application provides two major interfaces:

1. **Student Interface:** As shown in Figure 3, the interface enables users to interact with the chatbot and obtain answers to academic enquiries.
2. **Administrator Interface:** As shown in Figure 4, the interface allows administrators to manage the institutional knowledge base, update frequently asked questions, and monitor chatbot activities. The chatbot supports conversations related to:
 - i. Admission requirements
 - ii. Course registration
 - iii. Tuition fees
 - iv. Academic calendar
 - v. Examination regulations
 - vi. Faculties and departments
 - vii. Graduation requirements
 - viii. General university information

User Interface

The Figure 2 shows the developed intelligent chatbot system, which provides an intuitive and responsive interface that allows students to communicate naturally with the chatbot.

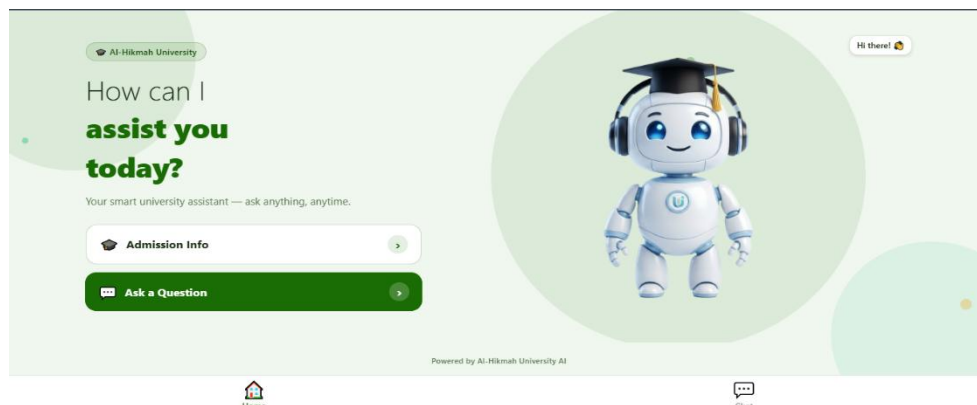


Figure 2: Home Page of the AI Chatbot

The homepage as shown in Figure 2 presents a clean interface introducing the chatbot and provides quick access to academic support services.

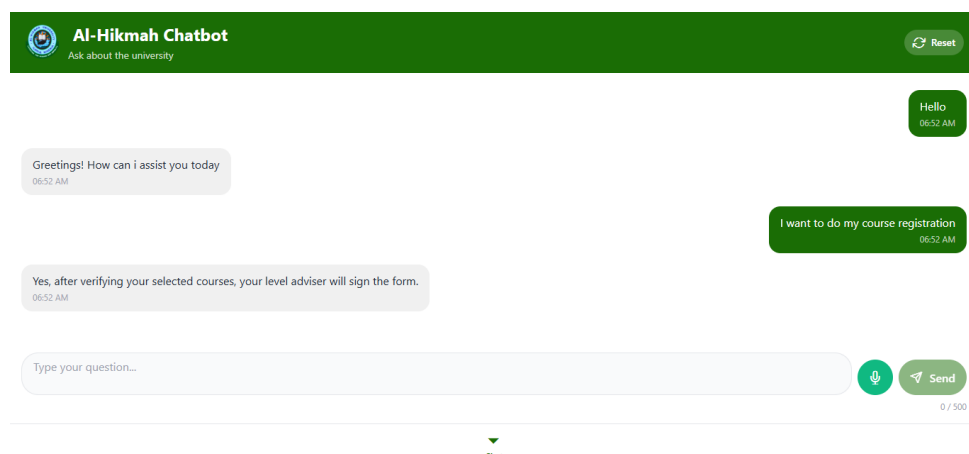


Figure 3: Student Chat Interface

The chat interface in Figure 3 allows users to type questions with accepted general language (English Language) while displaying responses in a conversational format similar to popular messaging applications.

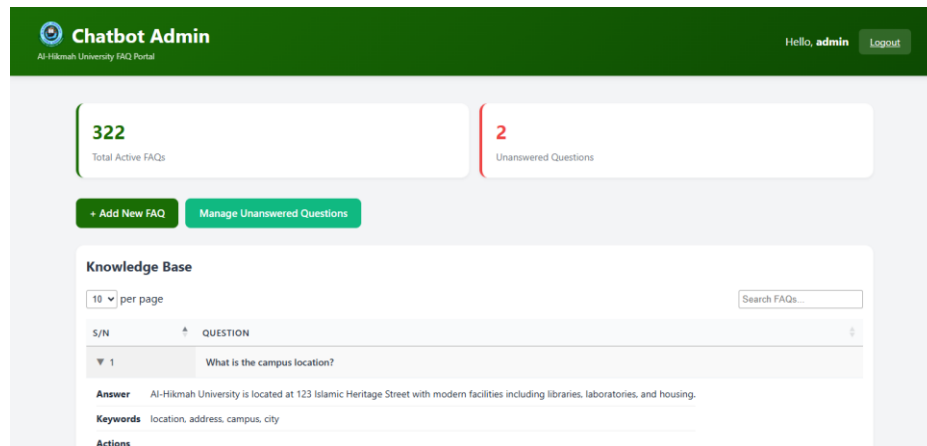


Figure 4: Administrator Dashboard

The administrator dashboard as shown in Figure 4 enables authorized personnel to manage chatbot content, update university information, and maintain the institutional knowledge base.

RESULTS AND DISCUSSION

This section presents the results outcomes of the implementation of the developed intelligent -based chatbot and evaluates its performance in supporting academic enquiries at Al-Hikmah University. The evaluation focuses on

system functionality, response accuracy, response time, usability, and overall effectiveness in improving access to institutional information.

Functional Testing

Functional testing was conducted to verify that each component of the chatbot performed according to the system requirements. The result of the functional testing is displayed in Table 2.

Table 2: Functional Testing Results

Function	Expected Result	Actual Result	Status
User Login	User authenticated successfully	Successful	Passed
Chat Interface	Accept user questions	Successful	Passed
NLP Processing	Interpret user intent	Successful	Passed
Gemini API Integration	Generate intelligent responses	Successful	Passed
Knowledge Base Retrieval	Retrieve relevant information	Successful	Passed
Admin Login	Authenticate administrator	Successful	Passed
Knowledge Base Update	Save updated information	Successful	Passed

The results of functional testing shown in Table 2 indicated that all core functionalities for expected result operated successfully without significant errors during testing.

Performance Evaluation

The chatbot was evaluated using common academic enquiries through the adapted questions in relation to performance evaluation of institutional academic resources; the responses were obtained from students. Table 3 details the response toward query categories.

Table 3: Sample Performance Evaluation

Query Category	Average Response Time (Seconds)	Response Accuracy
Admission Information	1.3	98%
Course Registration	1.4	97%
Tuition Fees	1.2	99%
Examination Information	1.5	97%
Academic Calendar	1.3	98%
Faculty Information	1.2	99%

The chatbot performance evaluation in Table 3 was consistently generated responses within approximately 1 to 2 **seconds**, which demonstrated real-time performance suitable for academic support services. Moreover, the performance evaluation indicates a high response accuracy result by combining institutional information stored in MongoDB with

Google's Gemini AI model, which ensured that responses remained contextually relevant and factually consistent.

Usability Evaluation

Usability testing involved representative users interacting with the chatbot to assess its effectiveness and ease of use. Table 4 shows the result of the usability evaluation.

Table 4: User Satisfaction Results

Evaluation Criterion	Rating
Ease of Use	Excellent
Interface Design	Excellent
Response Speed	Excellent
Information Accuracy	Very Good
Conversation Quality	Excellent
Overall Satisfaction	Excellent

Participants reported in Table 4 shown that the chatbot was intuitive and easy to use. The conversational interface reduced the effort required to obtain university information, while the natural language capability allowed users to ask questions in different ways without affecting response quality.

Generally, the results of the implementation have demonstrated that Artificial Intelligence can significantly improve academic support services within higher education institutions. Unlike traditional FAQ systems, the proposed chatbot understands accepted general language (English Language) queries and generates context-aware responses using Google's Gemini API. The integration of a verified institutional knowledge base further enhances response accuracy by ensuring that information provided to students aligns with official university policies.

The evaluation also shows that the chatbot reduces dependence on manual administrative support by providing immediate responses to frequently asked questions. This functional capability is particularly enhanced admission exercises, registration periods, and examination seasons when administrative offices experience high volumes of enquiries. Therefore, compared with earlier educational chatbot studies, the developed system provides several improvements:

- i. Integration of a modern Large Language Model (Google Gemini).
- ii. Institution-specific knowledge retrieval for improved accuracy.
- iii. Responsive web interface accessible from different devices.
- iv. Modular architecture supporting future expansion.
- v. Reduced administrative workload through automated academic support.

Overall, the findings indicate that the proposed chatbot successfully achieved the objectives of the study by providing reliable, accurate, and efficient academic support services. The results further demonstrate the potential of AI-powered conversational systems to enhance digital transformation initiatives within Nigerian universities.

CONCLUSION

The study successfully designed and implemented an intelligent-based chatbot for Al-Hikmah University using React.js, Node.js, Express.js, MongoDB, and Google's Gemini API to deliver instant, accurate, and context-aware academic support services, effectively handling enquiries related to admissions, course registration, tuition fees, academic calendars, examination regulations, and other university services while minimizing inaccurate information through integration of Natural Language Processing with a verified institutional knowledge base. Functional and usability evaluations demonstrated high response accuracy, fast response time, and positive user satisfaction, contributing to the digital transformation of higher education by reducing administrative workload, improving information accessibility, and providing continuous support beyond

working hours with greater efficiency, consistency, and scalability than traditional manual systems. Although the system achieved its design objectives, future enhancements may include multilingual capabilities, voice-based interaction, direct integration with the University's Student Information System, Retrieval-Augmented Generation with vector databases, mobile application deployment, and advanced analytics, collectively demonstrating that AI-powered conversational systems have significant potential to modernize academic support services in Nigerian universities and other higher education institutions seeking efficient, intelligent, and student-centered digital solutions.

REFERENCES

- Adamopoulou, E., & Moussiades, L. (2020, May). An overview of chatbot technology. In *IFIP international conference on artificial intelligence applications and innovations* (pp. 373-383). Cham: Springer International Publishing.
- Adigun, T., Eweoya, I., Sodi, K., Ajayi, O. F., Ayankoya, F., Akande, O., & Adetunji, O. (2025). Scalable and Real Time Embeddable Retrieval-Augmented Generation (Rag) Analytics System for Customer Service. *Fudma Journal of Sciences*, 9(10), 368-375.
- Bello, S. B., Bena, A. A., & Musa, H. Leveraging AI-Chatbots for Sustainable Development Goal IV: A Study of Polytechnic Lecturers' Perception and Usage Patterns.
- Benaddi, L., Ouaddi, C., Souha, A., Jakimi, A., & Ouchao, B. (2024, May). Chatbots in tourism sector: Classification, evolution, and functionalities. In *2024 IEEE 12th international symposium on signal, image, video and communications (ISIVC)* (pp. 1-6). IEEE.
- Eyikoro, Q., & Chigozie, J. N. (2024). Artificial Intelligence: A Resource Tool for Academic Service Delivery in Nigeria. *International journal of public administration and development studies*, 1(1), 17-29.
- Ndunagu, J. N., Ezeanya, C. U., Onuorah, B. O., Onyeakazi, J. C., & Ukwandu, E. (2025). A chatbot student support system in open and distance learning institutions. *Computers*, 14(3), 96.
- Peyton, K., Unnikrishnan, S., & Mulligan, B. (2025). A review of university chatbots for student support: FAQs and beyond. *Discover Education*, 4(1), 21.
- Rajendran, R. K., & Chitrarasu, K. (2024). Natural Language Processing (NLP) in chatbot design: NLP's impact on chatbot architecture. In *Design and Development of Emerging Chatbot Technology* (pp. 102-113). IGI Global Scientific Publishing.

- Swetha, C., Ismail, M., Anil, J., Venkatesh, K., & Rasheed, S. (2025, April). AI Powered Academic Assistant Using Conversational AI. In *2025 3rd International Conference on Advancements in Electrical, Electronics, Communication, Computing and Automation (ICAECA)* (pp. 1-5). IEEE.
- Tosho, A., Abdul Mutalib, A., & Nur Abdul Salam, S. (2014). Usability of instructional interface: Accessibility strategies of courseware design for distance learning, Nigeria. *International Journal of Computer Applications*, 106(18), 32-36.
- ul Haq, F., Asim, M., Suki, N. M., Zakaria, N., & Hussain, S. (2026). AI adoption and educational effectiveness in emerging higher education institutions: The moderating role of digital literacy and institutional support. *Journal of Information & Knowledge Management*, 25(03), 2550090.
- Ula, M., Hardi, R., & Hipiny, I. (2023). An Improved Structure for Academic Information Services through AI Chatbots. *Journal of Engineering Science & Technology Review*, 16(5), 164.
- Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education. *International Journal of Educational Technology in Higher Education*, 16(1), 39.

