



EduAssist: A Hierarchical Conversational Educational Recommendation (HCER) Framework for Personalized and Adaptive Learning

Shashank G¹, Gurudeep V², Vijay M³

Student, Department of Master of Applications, SJB Institute of Technology, Bangalore, India¹

Student, Department of Master of Applications, SJB Institute of Technology, Bangalore, India²

Student, Department of Master of Applications, SJB Institute of Technology, Bangalore, India³

Abstract: The growth of digital learning platforms has changed the way students look for knowledge and academic support. As these environments continue to expand, there is a rising demand for tools that can respond instantly and adapt to the needs of individual learners. Educational chatbots have emerged as one answer to this demand, offering students immediate answers, access to study resources, and academic guidance outside the traditional classroom. This paper presents EduAssist, a conceptual educational chatbot built around Natural Language Processing (NLP), designed to support personalized learning and sustained student engagement. By analyzing user queries through NLP techniques, the system is intended to generate relevant answers and recommend educational resources tailored to each learner's needs. Through the combination of conversational interaction, structured knowledge management, and voice-based accessibility, EduAssist aims to make independent study more approachable and consistent. Because this work presents a system design rather than a deployed application, the paper focuses on architecture, proposed functionality, and anticipated behavior, and identifies the steps — including prototype development and empirical evaluation — required to validate the framework in practice.

Keywords: Educational Chatbot, Natural Language Processing (NLP), Personalized Learning, Adaptive Learning, Conversational AI, Student Support Systems, Educational Technology, Intelligent Tutoring Systems, Learning Analytics, Artificial Intelligence.

I. INTRODUCTION

The growing presence of technology in education has reshaped how learners access information, engage with new material, and seek academic help. Among the tools driving this shift are educational chatbots powered by artificial intelligence. These systems are well suited to providing quick assistance and round-the-clock access to learning resources, which helps address longstanding barriers in education such as limited instructor availability, large class sizes, and inconsistent access to support outside scheduled class hours.

Natural Language Processing (NLP) is central to making these interactions feel intuitive, allowing a chatbot to interpret a student's question and respond in a way that matches its actual intent rather than matching surface-level keywords. As a result, educational institutions are increasingly exploring chatbot technology as a way to strengthen engagement, extend learning support beyond the physical classroom, and supplement the work of instructors rather than replace it.

This paper proposes EduAssist, an educational chatbot built on NLP techniques that is designed to answer academic questions and recommend suitable learning resources. The system is conceived as a combination of NLP-based query understanding, structured knowledge management, and a resource recommendation mechanism, aimed at producing a learner-centered tool that supports self-paced study.

This paper makes the following contributions:

- It proposes EduAssist, a unified conceptual framework that combines conversational query handling, structured knowledge retrieval, personalized resource recommendation, and voice-based interaction within a single system, rather than treating these as separate capabilities as much of the prior literature does.
- It presents a modular system architecture (five interoperating modules) intended to make the design extensible and adaptable to different educational domains and knowledge bases.



- It provides a comparative analysis positioning EduAssist against existing educational chatbots and virtual teaching assistants described in recent literature, highlighting the specific gaps the proposed design is intended to close.
- It identifies, explicitly, the limitations of a conceptual (non-implemented) design and lays out the empirical validation work required for future implementation.

Key objectives of this research are:

1. To design and propose an NLP-powered educational chatbot that provides intelligent and context-aware academic assistance to students.
2. To investigate the application of Natural Language Processing (NLP) techniques for understanding user queries and generating accurate educational responses.
3. To propose a personalized learning framework that recommends relevant educational resources based on students' learning needs and interests.
4. To enhance student engagement and self-directed learning through an interactive conversational interface that provides continuous academic support.

II. LITERATURE REVIEW

A. Educational Chatbots in Learning Environments

Educational chatbots allow students to get help at any time, answering questions and resolving doubts even when instructors are unavailable. Pinho and Primo [1] examined the intersection of chatbots and recommender systems in education and found that this combination improves learner engagement and helps students discover relevant content, though their review noted that conversational depth was often limited. This constant availability is one of the main reasons chatbots have been positioned as accessibility tools within digital learning environments.

B. Natural Language Processing in Educational Chatbots

NLP allows chatbots to interpret student questions in a more natural way instead of relying solely on keyword matching, producing more accurate responses and smoother conversations. Rao et al. [3] studied NLP-based educational chatbots and reported that NLP techniques meaningfully enhanced both interaction quality and learning support, although their system's accessibility and recommendation capabilities remained limited.

C. Personalized Learning Support

Because students differ in how they learn, chatbots capable of personalized support — tailored to individual learning patterns and interests — tend to make self-directed study more effective. This is one of the areas where conversational systems and adaptive systems are increasingly expected to converge, since recommending the right resource at the right time depends on an accurate model of what the learner already knows.

D. Virtual Teaching Assistants

AI-powered virtual teaching assistants extend support to students by answering questions, sharing study materials, and offering guidance outside class hours. Patel et al. [5] proposed a virtual teaching assistant chatbot for online education and found it effective for automated, real-time academic support, while also noting that its personalization capabilities were limited — a gap that recurs across much of this literature.

E. Research Gap

Although development in educational chatbots has been substantial, much of the existing literature concentrates on a single capability — either conversational interaction or resource recommendation — rather than combining both within one system. Alkishri et al. [2] and Jing et al. [6] both provide broad reviews of chatbot applications in education that reinforce this pattern: strong coverage of individual benefits and challenges, but limited discussion of integrated systems. In addition, the use of speech recognition to support conversational interaction with educational chatbots receives little attention in the reviewed literature, despite its potential to improve accessibility for learners who prefer or require voice-based interaction. Gabařová et al. [4] similarly point to AI's potential to support structured problem-solving in technical education, suggesting that integrated, subject-aware assistance is an area still open for development. EduAssist is proposed as a response to this combination of gaps.



Comparative Summary of Related Works

Paper	Technique	Focus / Reported Findings	Advantages	Limitations
Pinho & Primo, 2023 [1]	Educational Recommender Systems + Chatbots	Personalized learning recommendations	Improves learner engagement and content discovery	Limited focus on conversational learning
Alkishri et al., 2025 [2]	Conversational AI and Educational Chatbots	Review of chatbot applications in education	Identifies benefits and challenges of educational AI	Primarily a review study with no implementation
Rao et al., 2025 [3]	NLP-Based Educational Chatbots	Personalized learning through NLP techniques	Enhances student interaction and learning support	Limited accessibility and recommendation features
Gabařová et al., 2025 [4]	AI in Informatics Education	AI support for problem-solving tasks	Highlights AI's potential for structured technical learning	Domain-specific; not designed as a general conversational assistant
Patel et al., 2025 [5]	Virtual Teaching Assistant Chatbot	Automated student support using NLP	Provides real-time academic assistance	Limited personalization capabilities
Jing et al., 2025 [6]	Generative AI Chatbots in Education	Comprehensive analysis of chatbot applications	Supports knowledge and learning process management	Limited implementation details

TABLE I

III. PROPOSED SYSTEM DESIGN

A. Knowledge Base

The effectiveness of EduAssist depends heavily on the content of its knowledge base. This repository is intended to include educational content, FAQs, study material, and subject-wise content drawn from reliable educational sources such as textbooks, lecture notes, and online learning portals. Content is organized by subject and topic so that information stays easy to retrieve, and the knowledge base is designed to be expandable, allowing new material to be added over time rather than treating the dataset as static.

B. System Architecture

EduAssist follows a modular architecture built around five interoperating components: the User Interface Module, NLP Module, Knowledge Base Module, Response Generation Module, and Recommendation Module. Together, these modules handle the full cycle of a user interaction — from processing a query, to retrieving relevant information, to generating a response, to recommending further study material.

C. NLP Pipeline

The NLP module is the primary mechanism through which EduAssist interprets student input. When a user submits a query, it passes through text preprocessing, tokenization, key-phrase identification, intent recognition, and semantic analysis. Once the query's intent and context are established, the system retrieves relevant information from the knowledge base and constructs a response. This pipeline is intended to let students interact with the chatbot using ordinary, non-technical language rather than requiring structured or keyword-based input.



D. Recommendation Module

To support personalized learning, EduAssist includes a recommendation module that suggests educational resources based on user activity. The module is designed to evaluate past queries and inferred learning interests to identify topics that may need further exploration, and to surface tutorials, references, exercises, and other resources accordingly.

E. Recommendation Module

In order to facilitate personalized learning, EduAssist features a recommendation module that recommends suitable educational sources depending on the activities of the user. The module evaluates past searches and learning interests in order to determine areas which need more exploration. Accordingly, the system provides recommendations in the form of tutorials, references, exercises, and other learning sources.

F. System Workflow

The process flow of EduAssist starts with the submission of queries by the user using the chatbot portal. The queries are analyzed by the NLP component in order to understand the intent behind them and find keywords in the queries. The system looks up the knowledge base for related information and formulates a proper reply. Furthermore, the recommendation component also provides suggestions for related learning material which can help the students further.

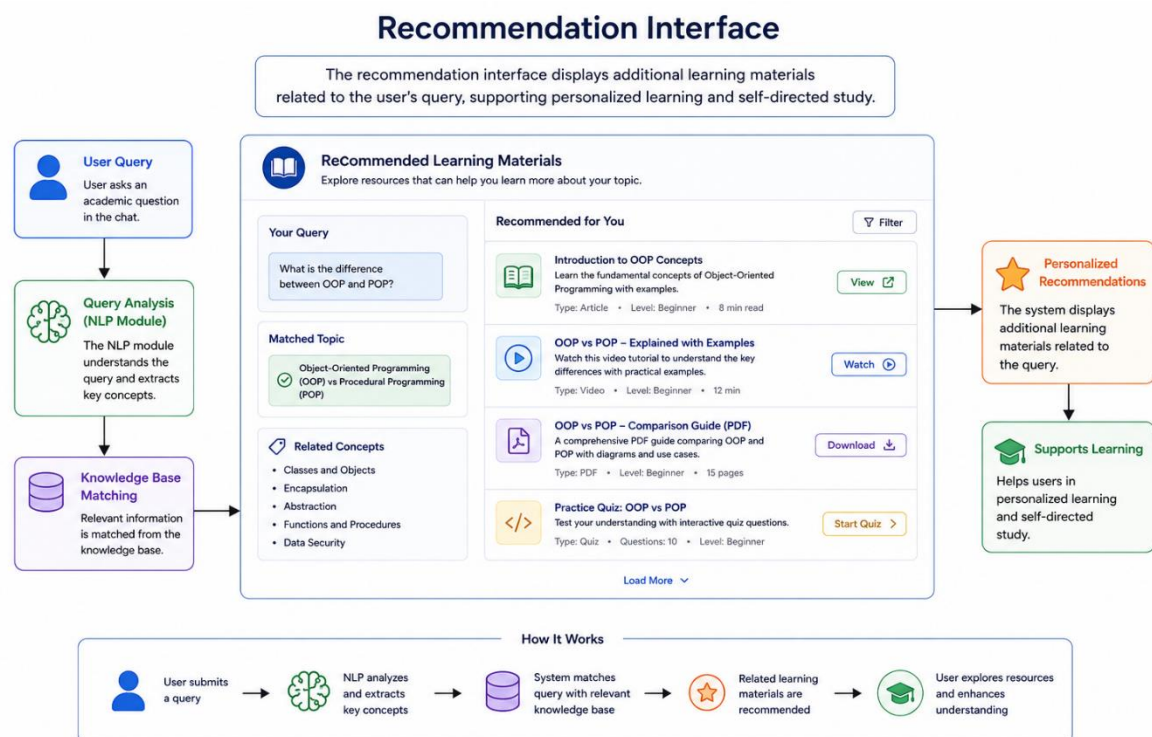


Fig. 1 Personalized Learning Resource Recommendations Interface

E. Voice Interaction Design

For accessibility, EduAssist is designed to support voice interaction alongside text input. Speech recognition tools would convert voice input into text for processing by the NLP module, with responses optionally converted back to speech. This is intended to make the system usable for learners who prefer spoken interaction or who benefit from reduced reliance on typing.

F. User Interface Design

The interface is designed to be accessible to learners without requiring technical expertise. A home page serves as the initial point of navigation, introducing users to the chatbot's services. From there, a live chat interface allows students to pose academic queries and receive contextually relevant responses, while a recommendation panel surfaces suggested learning resources alongside the conversation.



G. Technology Stack

The proposed technology stack combines Python — selected for its extensive AI and NLP libraries — with HTML, CSS, and JavaScript for the user interface, and SQLite for managing records of educational resources, FAQs, and user interactions. These choices were guided primarily by simplicity and flexibility, favoring tools that are well documented and straightforward to extend during future prototype development.

H. System Workflow

The end-to-end workflow begins when a user submits a query through the chatbot interface. The NLP module analyzes the query to determine intent and extract relevant keywords, after which the system searches the knowledge base for related information and formulates a response. The recommendation module then supplements this response with suggestions for related learning material, closing the loop between answering the immediate question and supporting continued study.

IV. ANTICIPATED SYSTEM BEHAVIOR

Because this paper presents a conceptual system design rather than a deployed application, this section describes the functionality each module is expected to provide, and how the proposed design compares with existing systems on paper — rather than reporting outcomes from formal evaluation or user testing.

A. Anticipated Functionality by Module

Table II summarizes the intended role of each module. The User Interface module is intended to enable conversational access between students and the chatbot. The NLP module is intended to analyze queries and determine user intent. The Knowledge Base module is intended to store and retrieve educational content efficiently. The Response Generation module is intended to construct contextually appropriate answers, and the Recommendation module is intended to suggest relevant learning materials based on query history. The Voice Interaction module is intended to extend all of the above to spoken input and output.

Component	Intended Functionality (Conceptual)
User Interface	Designed for conversational access
NLP Module	Intended to interpret intent from natural-language queries
Knowledge Base	Intended to store and retrieve subject-organized content
Response Generation	Intended to construct contextually relevant answers
Recommendation Module	Intended to suggest resources based on query history
Voice Interaction	Intended to extend interaction to spoken input/output

TABLE II

C. Anticipated User Experience

By design, EduAssist is intended to offer a convenient and interactive experience: students would ask questions in natural language and receive relevant responses without needing to search for information manually. The recommendation module is intended to extend this by surfacing related material, and the voice interaction feature is intended to add convenience for users who prefer spoken communication. As proposed, EduAssist is meant to function as a continuous point of academic support rather than a one-off question-answering tool.

Realizing this conceptual design would require building and testing a functional prototype; the table reflects intended behavior rather than measured performance.

B. Feature Comparison with Existing Systems

Table III compares EduAssist's proposed feature set against the capabilities commonly reported for existing educational chatbots in the literature reviewed in Section 2. Most existing systems handle academic queries reasonably well but offer limited personalization, resource recommendation, or voice interaction. EduAssist is designed to extend beyond query-answering into these underserved areas.



Feature	Existing Systems	EduAssist (Proposed)
Academic Query Support	Yes	Yes
Personalized Learning	Partial	Yes
Resource Recommendation	Limited	Yes
Voice Interaction	Limited	Yes
Learning Guidance	Partial	Yes

TABLE III

C. Anticipated User Experience

By design, EduAssist is intended to offer a convenient and interactive experience: students would ask questions in natural language and receive relevant responses without needing to search for information manually. The recommendation module is intended to extend this by surfacing related material, and the voice interaction feature is intended to add convenience for users who prefer spoken communication. As proposed, EduAssist is meant to function as a continuous point of academic support rather than a one-off question-answering tool.

V. FUTURE WORK

Several directions remain for extending this work beyond its current conceptual stage:

- Building and empirically testing a functional prototype to validate the design assumptions and functional claims made in this paper.
- Incorporating multilingual support so students can interact with the chatbot in multiple languages.
- Improving the recommendation engine through behavior-based personalization that adapts to individual user patterns and preferences over time.
- Integrating EduAssist with Learning Management Systems such as Moodle and Google Classroom to connect recommendations directly to enrolled coursework.

VI. CONCLUSION

This paper proposed EduAssist, an NLP-based educational chatbot designed to support personalized learning and continuous academic assistance through natural conversation. By combining natural language processing, structured knowledge management, and resource recommendation within a single architecture, the design aims to give learners more consistent access to guidance and study materials than either standalone chatbots or standalone recommender systems currently provide. The literature reviewed in this paper supports the broader claim that educational chatbots can improve learner engagement, accessibility, and self-paced learning, and the proposed EduAssist design builds directly on those findings. Confirming these benefits for EduAssist specifically, however, will depend on building and empirically evaluating a working prototype — work that is left for future research.

REFERENCES

- [1]. Pinho, A., & Primo, T. T. (2023). "Chatbots in Educational Recommender Systems: A Systematic Literature Review."
- [2]. Alkishri, A., Alharbi, A., & Alzahrani, S. (2025). „Conversational AI in Education: A General Review of Chatbot Applications, Benefits, and Challenges."
- [3]. Rao, P., Sharma, R., & Gupta, N. (2025). "NLP-Powered Chatbots for Personalised Learning Experiences."
- [4]. Gabařová, M., Kováč, P., & Novák, J. (2025). "Educational Applications of Artificial Intelligence: Supporting Problem Solving in Informatics Education."
- [5]. Patel, P., Alabdeli, H., Srinivas, V., et al. (2025). "AI-Powered Chatbots as Virtual Teaching Assistants in Online Education Using Natural Language Processing for Student Support."
- [6]. Jing, L., Zhang, Y., & Chen, D. (2025). "Chatbots in Educational Settings: A Comprehensive Literature Review."
- [7]. Devlin, J., Chang, M. W., Lee, K., & Toutanova, K. (2020). "BERT: Pre-training of Deep Bidirectional Transformers for Language Understanding."