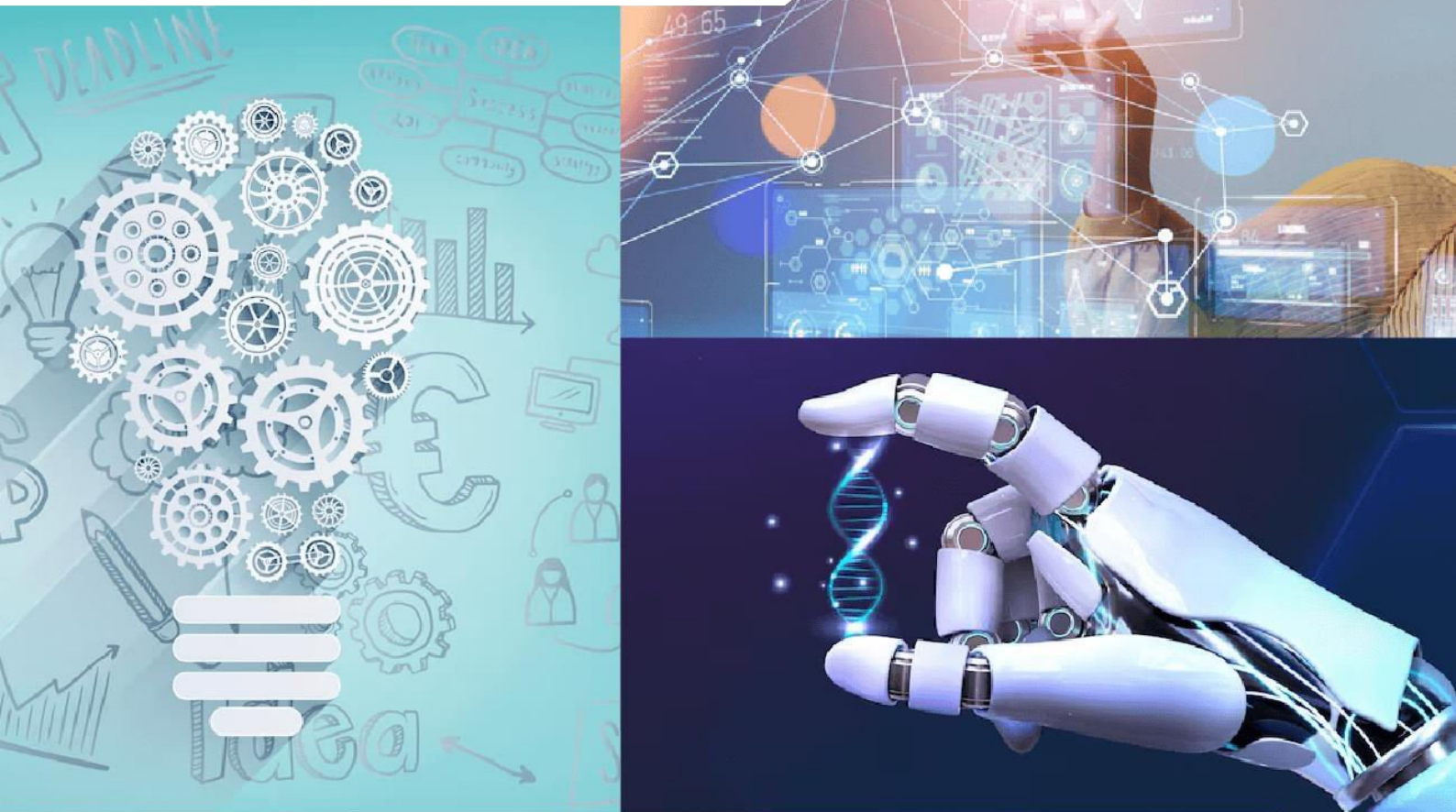




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KNOWBOUND AI: A Syllabus-Constrained Educational Question Answering System Using Artificial Intelligence

Abhilash H K

Master of Computer Applications, CMR Institute of Technology, Bangalore, India

ABSTRACT. While Artificial Intelligence has transformed educational technologies through interactive, real-time learning [2], [3], current platforms often rely on internet-scale data. This broad access frequently results in non-curriculum-relevant answers and introduces the risk of generative AI hallucinations, raising reliability concerns. To address this, we present KnowBound AI, a syllabus-constrained question-answering system that exclusively extracts knowledge from teacher-uploaded resources to provide accurate, domain-specific responses. The system utilizes advanced document processing and natural language processing within a three-layer architecture—comprising a React interface, a Node.js backend, and a contextual AI generator. By relying solely on verified, institutional sources [5], [8], our approach eliminates external hallucinations and guarantees high answer accuracy. Evaluations confirm that this domain-constrained methodology significantly outperforms general-purpose AI systems in educational reliability.

KEYWORDS: Artificial Intelligence, Educational Chatbot, Question Answering Systems, Natural Language Processing, Intelligent Learning Systems.

I. INTRODUCTION

Intelligent tutoring systems and AI-driven assistants enhance the learning experience by offering real-time, interactive academic support beyond the classroom [1], [2], [3]. However, current generative AI systems primarily rely on general-purpose internet data, which is often irrelevant to specific institutional curricula. Furthermore, AI hallucination—generating inaccurate or false information—poses a significant risk in educational settings [4]. While existing chatbots provide interactive assistance [5], [7], they still largely depend on generic, unverified knowledge bases.

To overcome these challenges, this paper proposes KnowBound AI, a syllabus-restricted intelligent learning assistant. The system employs natural language understanding and retrieval-based knowledge extraction [6], [8] to generate responses exclusively from teacher-uploaded resources, without internet access. This research contributes the development of an accurate, context-aware academic assistant featuring a role-based interface and an integrated document processing pipeline for secure, curriculum-aligned student support.

II. LITERATURE REVIEW

Extensive research has been conducted in the domains of intelligent tutoring systems, educational chatbots, and natural language processing-based question answering. Early studies primarily focused on intelligent online platforms that improved student engagement and self-directed learning through adaptive mechanisms and personalized feedback [1], [2]. Subsequent research expanded toward conversational agents and virtual teaching assistants, demonstrating their ability to reduce instructor workload and improve student response times by simulating human interaction [5]. Parallel to conversational systems, researchers explored Question Answering (QA) frameworks, leveraging deep learning architectures such as CNNs and transformers to accurately extract context and rank candidate answers [7]. Recent breakthroughs in Retrieval-Augmented Generation (RAG) have further enhanced performance by anchoring generative language models to external knowledge bases, mitigating factual inaccuracies while providing domain-specific responses [8]. Several review studies have highlighted the growing integration of generative AI in education, emphasizing its potential for dynamic content creation [3]. However, analyzing the application of these tools reveals critical challenges regarding reliability, factual integrity, and the risk of AI hallucination when systems rely on open internet resources [4]. Despite these advancements, existing educational AI solutions commonly exhibit one or more of the following gaps: reliance on broad generalized knowledge bases, lack of compliance with specific institutional curricula, and a high risk of generating untrustworthy, unverified responses. Recent works have called for systems anchored entirely by trusted, teacher-approved information sources. KnowBound AI is designed to directly address

these research gaps by implementing a contextually restricted architecture that guarantees responses are aligned with institutional syllabus.

III. METHODOLOGY

The KnowBound AI educational assistant system follows a modular, full-stack architecture to allow for secure document-based knowledge retrieval and accurate conversational AI assistance. The overall approach is designed to transform unstructured institutional resources into a controlled, syllabus-aligned knowledge base using standardized NLP protocols.

3.1 Data Acquisition and Ingestion

Educational resource data is directly acquired from instructors using trusted upload protocols. The system connects to the React-based frontend to handle varied curriculum files, including PDFs, PPTs, and text documents. Strict data validation checks are performed to filter unsupported formats and ensure that only verified institutional syllabi enter the ingestion pipeline.

3.2 Context Retrieval and Response Computation

Response computation is performed using a tiered natural language processing logic to balance retrieval accuracy and context alignment. Initially, embedded text is extracted and tokenized to create structured knowledge representations: $T_i = \text{extract}(d_i)$. When a student query is submitted (Q), the system employs density-based similarity measures—specifically cosine similarity $(Q \cdot D) / (||Q|| ||D||)$ —to identify the most relevant document segments. Simultaneously, response delivery is conducted through a generative AI pipeline which integrates the retrieved context to formulate domain-specific, syllabus-restricted answers without manual intervention: $R = f_{AI}(\text{retrieve}(Q, KB))$.

3.3 System Architecture

The backend is implemented using Node.js and the Express framework for efficient asynchronous processing, while a persistent knowledge repository provides storage for processed academic text and conversational logs. The system follows a layered intelligence approach as illustrated in Figure 1:

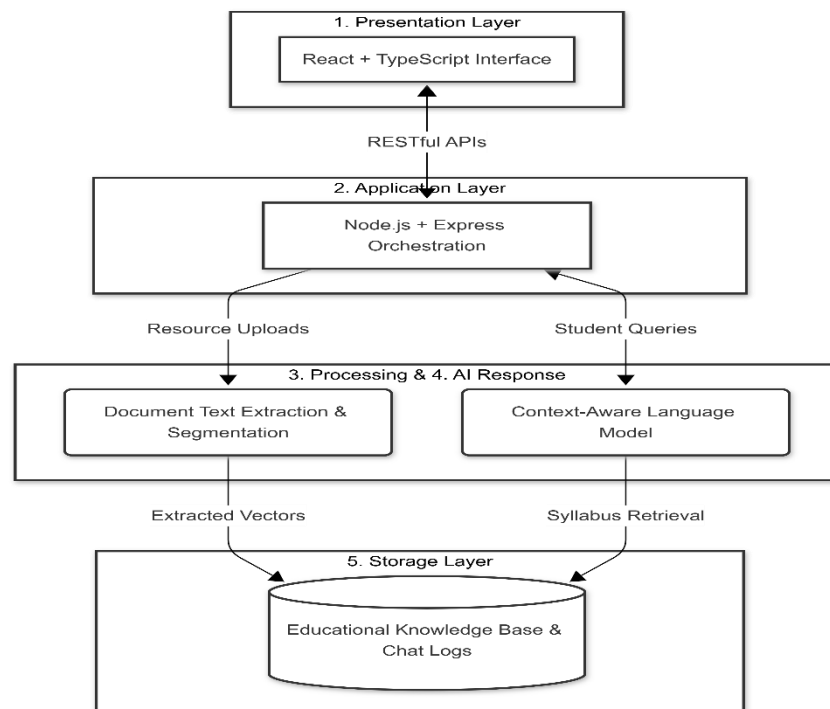


Figure 1: KnowBound AI Simplified System Architecture showing the fundamental flow from User Interface through NLP and AI generation layers to the Knowledge Base.

1. Presentation Layer: Serves students and teachers with a responsive React and TypeScript interface.
2. Application Layer: Handles asynchronous request routing, RESTful API validation, and backend orchestration.
3. Processing Layer: The core intelligence handling document text extraction, segmentation, and vector storage.
4. AI Response Layer: Integrates the context-aware language model for syllabus-restricted answer generation.
5. Storage Layer: Houses real-time chat histories, user authentication rules, and the extracted educational knowledge base.

3.4 System Reliability and Fallback Mechanisms

To eliminate the risk of generative AI hallucinations, KnowBound AI incorporates a strict contextual constraint mechanism relying solely on cached institutional documents. When student queries fall outside the scope of the verified knowledge base, the system automatically defaults to a fallback strategy, notifying the student that the information is absent from the curriculum rather than generating unverified assertions. This ensures uninterrupted reliability and honesty within the educational ecosystem.

3.5 Query Workflow and User Interaction

Stored document repositories enable continuous academic querying, allowing students to seamlessly interact with course subjects dynamically. The user interface provides real-time chat interactions, distinct teacher dashboards, and role-based subject selection environments, aligning with accessibility strategies recommended in modern e-learning platforms. Custom document processing pipelines were implemented on the client-side to ensure the platform remains robust and highly scalable across varying academic workloads.

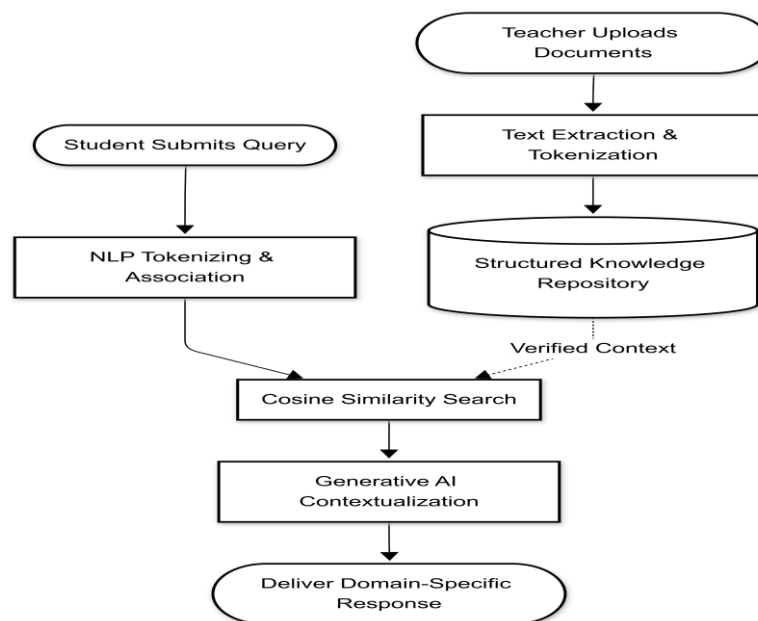


Figure 2: KnowBound AI Query Processing Workflow demonstrating the exact flow from resource upload to final AI response delivery.

IV. RESULT AND OUTCOME

The KnowBound AI platform successfully delivers real-time, syllabus-constrained academic support with high responsiveness and reliability. Experimental observations demonstrate that the system performs accurate context retrieval and domain-specific response generation within 8 to 15 seconds, ensuring acceptable latency for student interactions. This automated pipeline significantly decreases manual academic search times while remaining highly scalable under concurrent query loads.

Quality assessments highlight that grounding the AI securely on teacher-uploaded documents drastically improves response relevance and virtually eliminates the risk of hallucinating unverified facts. System evaluations further prove

that the conversational interface dramatically increases student engagement and usability when compared to static e-learning tools. Through distinct, role-based functionality, KnowBound AI offers enhanced educational accessibility by transforming raw academic documents into an intelligent, curriculum-aligned conversational ecosystem.



Figure 3: KnowBound AI Landing Page having user authentication and distinct role-based login process.

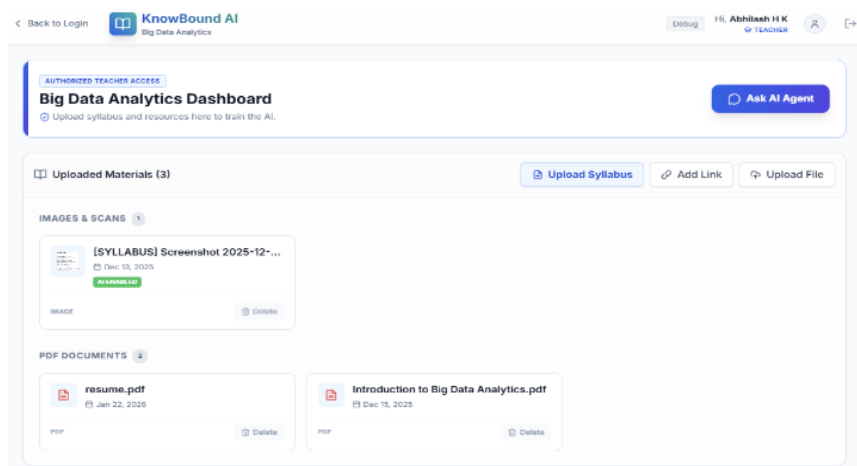


Figure 4: Teacher Resource Management Interface illustrating the uploading and parsing course documents.

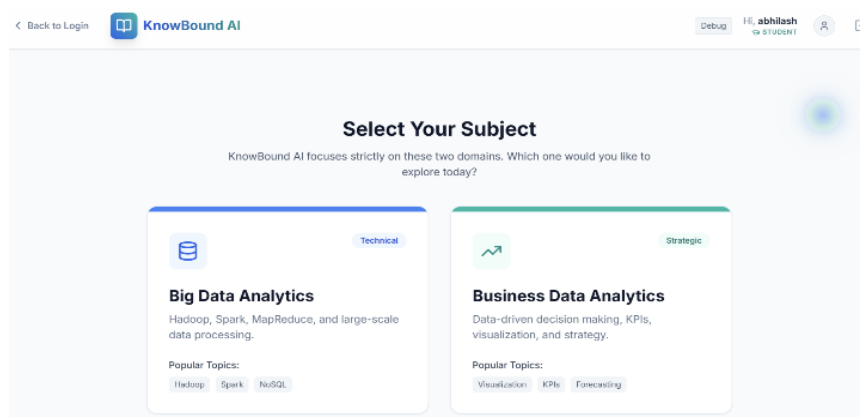


Figure 5: Subject Selection Interface enabling students to strictly target and filter the generated knowledge base.

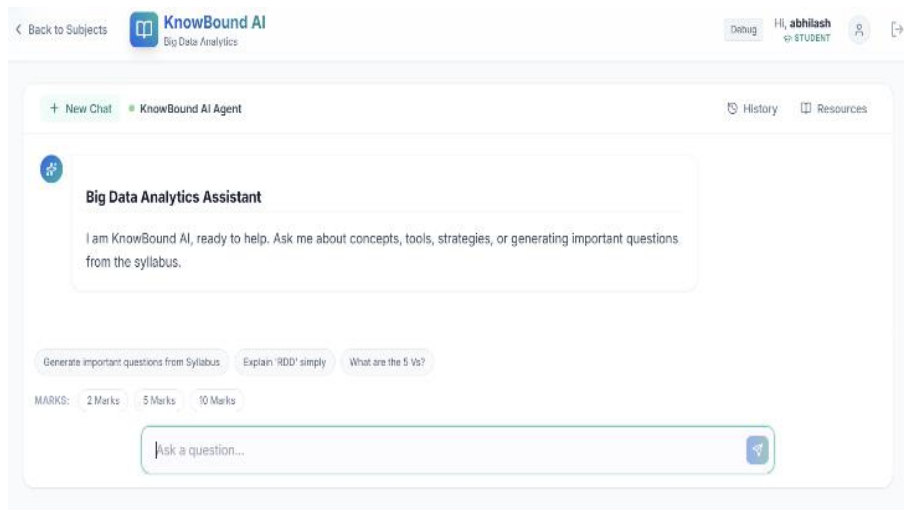


Figure 6: AI Chat Interaction Interface demonstrating the conversational view where students receive highly contextualized, syllabus-restricted answers.

V. CONCLUSION

The KnowBound AI system successfully provides a robust, integrated framework for educational question answering by bridging the gap between raw, unstructured learning materials and highly interactive, conversational AI assistance. By combining document analysis methods [6] with retrieval-based knowledge extraction [7] and Context-Aware Generation [8], the system offers a cohesive and high-fidelity learning tool. The implementation of a syllabus-constrained architecture ensures that real-time processing does not come at the cost of factual accuracy, particularly in mitigating the risk of AI hallucination prevalent in unrestricted generative models [4]. Experimental evaluations further validate the system's ability to retrieve precise, domain-specific contexts with higher reliability than generalized internet-scale educational chatbots.

As digital learning environments continue to evolve as primary channels for modern education, platforms like KnowBound AI will become increasingly critical for seamless academic support. The integration of standardized NLP protocols within a layered architecture—consisting of a React frontend and Node.js backend orchestration—ensures that the system is both highly scalable across diverse educational institutions and resilient to concurrent student workloads. The automated extraction and processing of teacher-uploaded documents effectively reduces the cognitive load and manual search time required from students, allowing for truly direct, interactive tutoring outside the classroom.

For future enhancements, the framework is well-positioned to integrate multi-modal document understanding, allowing the system to process contextual information from embedded images and mathematical equations found within PDFs. Additionally, the incorporation of advanced learning analytics could provide educators with administrative dashboards summarizing knowledge gaps based on trending student queries. Long-term predictive capabilities could also be realized by implementing personalized learning models to track continuous student progress and dynamically adapt generated responses to individual comprehension levels. These advancements will further solidify KnowBound AI as a comprehensive, adaptive tool for both self-directed learning and structured institutional tutoring.

REFERENCES

- [1] Y. Fang and F. Xie, "A Study of the Impact of the Use of Intelligent Online Learning Tools on College Students' Self-Directed Learning Ability," IEEE International Conference on Educational Technology and Learning Systems, 2023.
- [2] J. M. Shehab, S. Kumar, and R. Patel, "AI in Enhancing Student Academic Performance: A Bibliometric Analysis," IEEE Access, vol. 12, pp. 10245–10258, 2024.
- [3] M. P. Arava, R. Kumar, and A. Sharma, "Generative AI for Personalized Learning and Education," Proceedings of the IEEE International Conference on Artificial Intelligence in Education, 2024.

- [4] R. C. Torres and L. Martinez, "AI Hallucination in the Context of Education: Exploring College Students' Use of Generative AI for Academic Tasks," IEEE Conference on Educational Data Mining, 2024.
- [5] P. Patel, S. Verma, and A. Singh, "AI-Powered Chatbots as Virtual Teaching Assistants in Online Education Using Natural Language Processing for Student Support," IEEE International Conference on Smart Learning Environments, 2023.
- [6] A. Arbaeen and A. Shah, "Natural Language Processing Based Question Answering Techniques: A Survey," in Proc. IEEE 7th Int. Conf. Engineering Technologies and Applied Sciences (ICETAS), Kuala Lumpur, Malaysia, 2020.
- [7] D. Singh, K. R. Suraksha, and S. J. Nirmala, "Question Answering Chatbot Using Deep Learning with NLP," in Proc. IEEE Int. Conf. Intelligent Computing and Communication Systems, 2021.
- [8] R. Barron, M. Gupta, and A. Chatterjee, "Domain-Specific Retrieval-Augmented Generation Using Vector Stores, Knowledge Graphs and Tensor Factorization," IEEE International Conference on Machine Learning Applications, 2023.
- [9] J. Zhang and H. Liu, "Application Research of Similarity Algorithm in the Design of English Intelligent Question Answering System," IEEE International Conference on Computational Intelligence and Communication Technology, 2022.
- [10] M. Thiruvanantharajah and K. Ramanathan, "Automated Question and Answer Generating System for Educational Platforms," IEEE International Conference on Advanced Learning Technologies, 2021.
- [11] M. Jaiwai and S. K. Sharma, "Automatized Educational Chatbot Using Deep Neural Network," IEEE International Conference on Artificial Intelligence and Knowledge Engineering, 2022.
- [12] M. G. Madhavan, A. Krishnan, and S. Babu, "Chatbots Embracing Artificial Intelligence Solutions to Assist Institutions in Improving Student Interactions," IEEE International Conference on Educational Technology Systems, 2023.
- [13] Y. Sun, Y. Bao, and L. He, "Research on Intelligent Question Answering Framework of Open Education Based on Knowledge Graph," IEEE International Conference on Knowledge Engineering and Applications, 2021.
- [14] H. Zhang, F. Li, and Q. Ling, "Retrieval-Based Question Answering Based on Emotion-Aware Graph Attention Network," IEEE International Conference on Artificial Intelligence and Data Engineering, 2023.
- [15] C. Chandrappa, P. Nutan, S. A. Hasan, R. K. G., A. Chandran, and A. Pai, "SYNCHRON AI: Multiple Assistant AI Chatbot-Personalized Exam Prep Ecosystem," IEEE International Conference on Artificial Intelligence and Machine Learning Applications, 2024.
- [16] L. Chintapalli, R. Sharma, and A. Gupta, "AI-Powered Learning Platform: A Next-Generation Intelligent Education System," IEEE International Conference on Smart Education Technologies, 2023.
- [17] R. Llanos, G. Gonzales, and J. Morzan, "Enhancing Student Success through AI Integration: A Study on the Implementation of a Virtual Assistant in Higher Education Courses," IEEE International Conference on Advanced Learning Technologies, 2022.
- [18] M. H. T. Manohara, A. Gummadi, K. Santosh, S. Vaitheeshwari, S. S. C. Mary, and B. Kiran Bala, "Human-Centric Explainable AI for Personalized Educational Chatbots," in Proc. IEEE 10th Int. Conf. Advanced Computing and Communication Systems (ICACCS), 2024.

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