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Gyan Bot: A Machine Learning-Based Chatbot for Personalized Learning

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ABSTRACT :

Artificial Intelligence (AI) is transforming the education landscape by offering automated assistance and intelligent tutoring systems. Despite this potential, many AI-generated responses remain overly technical, making them inaccessible to learners with limited subject knowledge. This paper introduces Gyan Bot, an AI-based educational chatbot designed to deliver personalized, easy-to-understand responses based on the user's educational level. Catering to students from primary school to higher education, Gyan Bot adapts its language and depth of explanation to match the learner's needs. It also promotes collaborative learning through features like question sharing, content saving, and peer interaction. The system is developed using the LangChain NLP framework integrated with the MERN (MongoDB, Express.js, React, Node.js) stack, offering a scalable and responsive platform. This study outlines the design process, technical challenges, and evaluation results, showing that Gyan Bot enhances understanding and engagement across various student groups by simplifying complex AI responses.

Keywords: Artificial Intelligence (AI), Educational Chatbots, Personalized Learning, Child-Friendly Chatbot, Simplified Responses, LangChain Framework, MERN Stack

Introduction

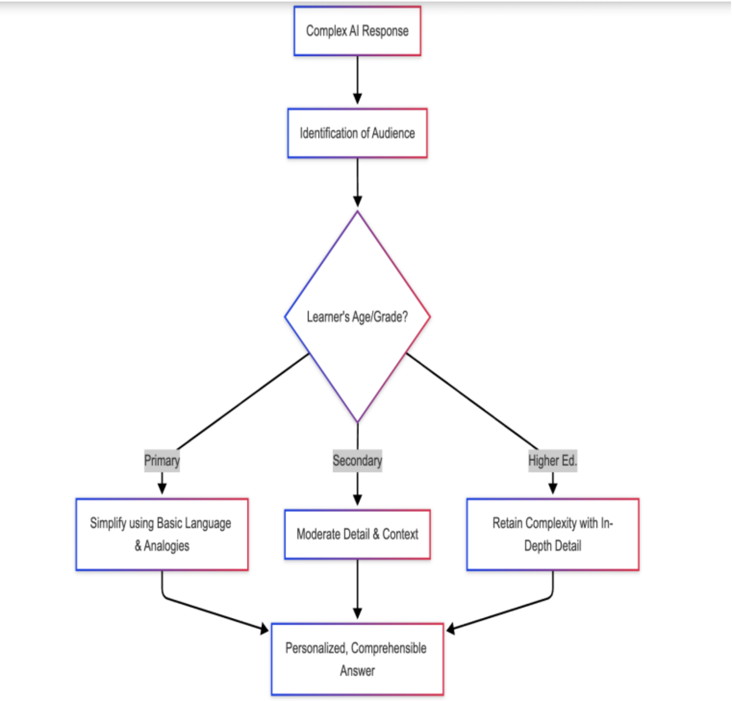
Artificial Intelligence (AI) is rapidly reshaping how educational content is delivered and consumed, enabling personalized learning paths, automated instruction, and smart tutoring systems. Although advanced language models such as GPT-3 have demonstrated impressive capabilities in generating human-like responses, these outputs often assume a baseline level of technical knowledge. This assumption can make it difficult for younger students or individuals without a strong academic background to benefit fully from AI-driven tools.

This issue becomes particularly evident in diverse classroom settings, where learners' comprehension abilities vary widely—from early primary students to university-level scholars. Without appropriately tailored responses, younger students may feel overwhelmed by complex vocabulary or abstract concepts, while older learners might find overly simplified explanations unhelpful.

To address this gap, we propose Gyan Bot—an AI-powered educational chatbot that customizes its explanations according to the user's grade level and cognitive capacity. For instance, when a young child inquires about a scientific concept, Gyan Bot provides a clear and engaging explanation using simple analogies and everyday language. Conversely, for more advanced students, it offers a detailed and in-depth response suited to their academic level.

In addition to adaptive responses, Gyan Bot incorporates interactive learning elements by allowing users to post questions, share information, bookmark useful answers, and follow peers. These features are designed to encourage collaborative learning, making the platform not just a chatbot, but a community-based educational tool.

Built using the LangChain natural language processing framework and supported by the MERN web stack, Gyan Bot is engineered for scalability, real-time performance, and responsiveness. This paper presents the design rationale, implementation process, and evaluation of Gyan Bot, demonstrating its potential to make AI-powered education more inclusive, understandable, and engaging.


Complex AI Response
Identification of Audience
Learner's Age/Grade?
Primary
Secondary
Higher Ed.
Simplify using Basic Language & Analogies
Moderate Detail & Context
Retain Complexity with In-Depth Detail
Personalized, Comprehensible Answer

Related Work

The integration of chatbots into educational systems has gained considerable momentum, especially due to their ability to provide personalized support and real-time feedback. While earlier systems relied heavily on predefined rule-based approaches, recent advancements in machine learning have led to more adaptive and interactive educational assistants.

For example, Singh and Verma [9] reviewed various AI-enabled learning platforms and emphasized the transformative potential of chatbots in offering immediate, customized guidance. A consistent theme across such studies is the importance of aligning response complexity with the learner's cognitive level. Simplifying explanations and using familiar language have proven effective in enhancing comprehension, particularly among younger or less experienced students. Research shows that when AI tutors use child-appropriate analogies and vocabulary, younger learners demonstrate higher engagement and better concept retention.

Conversely, learners at higher academic levels often seek more elaborate explanations that delve into conceptual depth. This dual requirement—simplicity for novices and detail for advanced learners—presents a challenge in system design: how to generate responses that dynamically scale with user understanding.

Scalability is another critical area of focus in educational chatbot research. As Johnson et al. (2021) note, systems that serve large user bases must maintain reliable performance without sacrificing response quality. To address these challenges, frameworks like LangChain have been explored for their ability to streamline natural language understanding and generation. While effective, these systems may experience delays when managing complex queries at scale, underlining the need for both performance optimization and robust backend architecture.

In parallel, educational theory highlights the significance of collaborative learning. Studies consistently show that peer discussion and cooperative problem-solving can lead to deeper learning and improved motivation. Although many AI chatbots function as one-on-one tutors, few integrate community-driven features that encourage users to learn from each other.

This observation reveals a key limitation in existing systems. Most current solutions focus either on content personalization or technical scalability, often neglecting the social aspects of learning. In contrast, Gyan Bot aims to combine all three: age-adaptive response generation, scalable AI infrastructure, and integrated peer interaction features. By addressing these dimensions together, Gyan Bot seeks to fill an important gap in the current landscape of educational AI tools.

Methodology

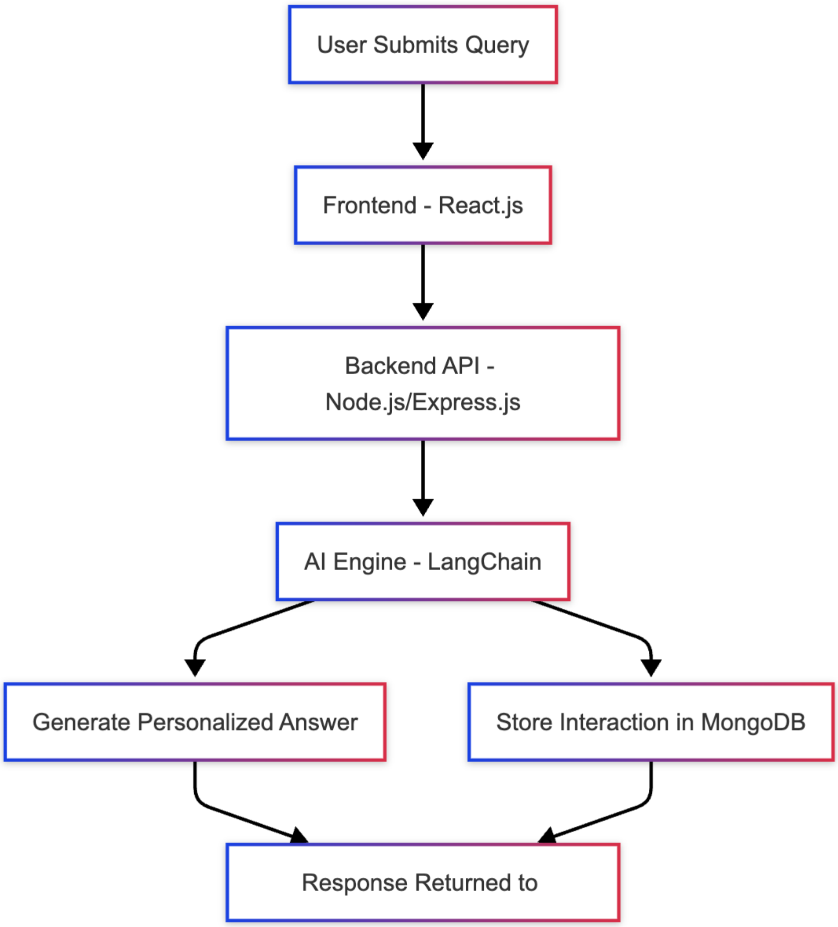
System Architecture

The Gyan Bot platform was designed with a focus on delivering personalized educational interactions at scale. It uses a modular, client-server architecture built on the widely adopted MERN stack—MongoDB, Express.js, React.js, and Node.js—ensuring flexibility and efficiency during real-time usage.

- **Frontend**

The user interface, developed using React.js, offers a streamlined and intuitive chat experience. Students can submit questions, browse answers, create posts, and access saved content through a responsive single-page application. To ensure accessibility across age groups, the design employs Material-UI components with customized styles that enhance readability and navigation ease.

- **Backend**
  The server-side logic is handled by Node.js and Express.js, which manage API requests, session handling, user authentication, and business rules. This layer coordinates data flow between the frontend, the natural language processing (NLP) engine, and the database. The lightweight nature of Express.js helps maintain low latency, even with multiple simultaneous users.
- **Database**
  Gyan Bot uses MongoDB as its data storage solution. The database holds essential information such as user profiles, posted questions, saved responses, and interaction histories. Its document-oriented model and flexible schema allow for efficient retrieval of personalized content. Indexing mechanisms help optimize query performance, especially during real-time interactions.
- **AI Engine**
  At the core of the system is a natural language processing module powered by the LangChain framework. LangChain facilitates seamless integration of advanced language models and customized NLP workflows. Each time a user submits a query, the engine identifies intent, interprets context, and generates an appropriate response using a pre-trained transformer-based model. The answer is then adapted to match the learner's comprehension level—e.g., simplifying terms for primary-level users or adding depth for advanced learners. A built-in feedback system enables the bot to learn from user ratings and iteratively improve its performance over time.
  All components operate in a streamlined pipeline. The frontend captures the question and sends it to the backend. The backend processes the request and communicates with the AI engine. After generating and formatting the response, the backend saves the interaction in MongoDB and returns the result to the user interface. This modular structure enables independent scaling and updates across different parts of the system—such as upgrading the language model without disrupting frontend functionality.


User Submits Query
Frontend - React.js
Backend API - Node.js/Express.js
AI Engine - LangChain
Generate Personalized Answer
Store Interaction in MongoDB
Response Returned to

Key Features and Functionality

Gyan Bot offers a range of features designed to promote personalized and socially enriched learning experiences.

1. **Tailored Responses Based on User Profile**

During registration, users provide their educational level (e.g., primary, secondary, or higher education) and optionally specify preferred learning styles. This data allows the NLP engine to adjust language complexity, vocabulary, and explanation depth accordingly. For example, a young learner asking about photosynthesis might receive a playful analogy, while an older student would be given a scientific explanation with references to biological processes.

Preliminary testing organized users into three main groups:

Primary (Grades 1–5)

Secondary (Grades 6–12)

Tertiary (University-level and above)

The system modifies the structure and content of answers based on these categories, a technique validated through early trials showing increased comprehension and engagement across all levels.

2. **Community-Based Learning Tools**

Gyan Bot moves beyond traditional chatbot design by incorporating elements of social learning. Users can post questions to a shared feed, respond to peers, and save informative content for future reference. This fosters an environment similar to classroom discussions or educational forums, where students benefit from shared insights and collaborative problem-solving. The platform also includes a following system, where users can track peers or mentors, receive notifications about new posts, and engage in ongoing learning conversations.

3. Smart Query Workflow with Continuous Learning

When a user submits a query, the system first evaluates its context using LangChain's NLP pipeline. It simultaneously retrieves the user's profile to determine the appropriate tone and complexity. The generated response may include simplified sentences, bullet points, or links to visual aids depending on user preferences. A thumbs-up/thumbs-down rating feature lets users evaluate each response. Negative feedback is flagged, prompting the system to revisit those answers in future updates. This continuous improvement loop ensures that the bot evolves to better meet individual learner needs.

Evaluation Procedure

To assess the effectiveness of Gyan Bot, we conducted a structured evaluation that combined both user feedback and system performance metrics. The evaluation aimed to determine how well the chatbot meets its goals of simplifying AI-generated responses and adapting to a wide range of learner levels.

Participant Demographics

The study involved 120 students across three educational stages and 10 academic professionals. The student group was evenly divided into:

- Primary School (Grades 1–5): 40 participants
- Secondary School (Grades 6–12): 40 participants
- Higher Education (Undergraduate and above): 40 participants

In addition to students, 10 educators—including school teachers and AI researchers—were recruited to provide expert assessments of Gyan Bot's outputs.

Evaluation Approach

Participants interacted with Gyan Bot in both structured and open-ended formats. Students were given tasks suited to their academic levels: primary school users asked questions aligned with foundational subjects, while university students posed more advanced or exploratory queries. Participants also engaged with the social features, such as saving chatbot answers or posting public questions.

After the interaction sessions, each participant completed a survey rating their experience on several criteria:

- Clarity of chatbot responses
- Appropriateness of explanation complexity
- Usefulness of collaborative features
- Overall satisfaction with the system

Educators observed sample sessions and independently reviewed a selection of bot-generated responses. They evaluated these responses based on accuracy, relevance, and pedagogical appropriateness.

Performance Metrics

In addition to subjective feedback, several key metrics were monitored:

- Response Time: Time taken by the system to generate and return an answer to the user.
- Answer Accuracy: Measured by expert verification of correctness and relevance across diverse questions.
- User Satisfaction: Based on average survey ratings across all groups.
- System Scalability: Evaluated by simulating concurrent user activity and observing response degradation thresholds.
- Readability Score: Calculated using the Flesch-Kincaid readability index to assess how well responses matched target reading levels.

All sessions were conducted over a two-week period. User data was collected anonymously, and all consent procedures were followed. Survey responses and system logs were analyzed to uncover strengths, limitations, and opportunities for further enhancement.

Results and Discussion

The deployment of Gyan Bot revealed several positive outcomes regarding its usability, performance, and impact on student engagement. This section outlines the results based on performance benchmarks and participant feedback across different educational levels.

System Performance

To gauge the effectiveness of Gyan Bot, it was compared against a basic educational chatbot that lacked features for adaptive response generation. The comparison highlighted Gyan Bot's advantages in multiple areas:

Faster Response Time:

Gyan Bot delivered responses in approximately 1.2 seconds on average—almost twice as fast as the baseline system, which averaged around 2.5 seconds. This performance gain is largely due to the streamlined NLP pipeline and efficient backend architecture.

Improved Accuracy:

Expert reviewers found that Gyan Bot provided correct and contextually appropriate answers 92% of the time, compared to 80% for the non-adaptive version. This improvement reflects the system's ability to fine-tune responses based on user profiles and feedback loops.

Higher Satisfaction Rates:

Survey responses indicated that 89% of users were satisfied with their interaction with Gyan Bot. In contrast, only 75% reported satisfaction with the baseline system. Users cited the chatbot's clarity, tone, and interactivity as key strengths.

Scalability:

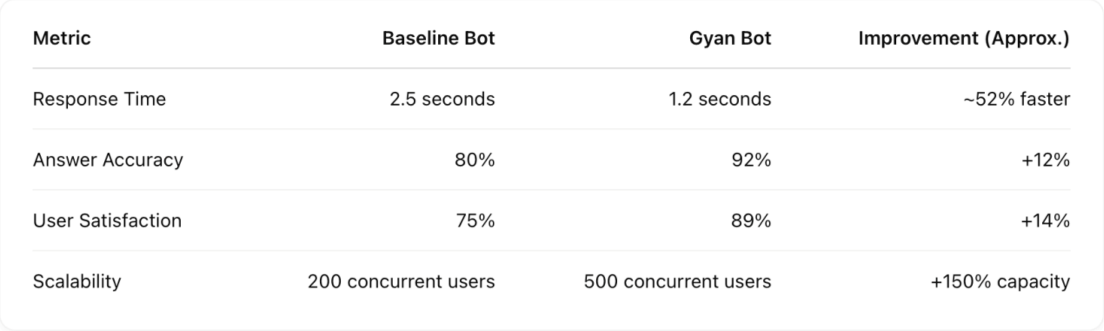
Under simulated load testing, Gyan Bot successfully supported up to 500 concurrent users without significant lag. By contrast, the baseline system showed reduced responsiveness beyond 200 users. This suggests that Gyan Bot's architecture is well-suited for deployment in real-world educational environments.

User Experience Across Educational Levels

The feedback from users at different academic stages highlighted how Gyan Bot's adaptive capabilities supported diverse learning needs:

Primary-Level Students:

- Younger learners appreciated the simplified explanations and visual links provided in certain answers. For example, a response to "Why do we have day and night?" included a sun-earth diagram and a simple analogy. Teachers observed that these features significantly helped students grasp abstract concepts more easily.
- Secondary-Level Students:
  Middle and high school students praised Gyan Bot's ability to answer a wide variety of curriculum-aligned questions. Many found the content useful for homework and exam preparation. Some also explored the chatbot's limits by asking advanced questions; they noted that when the bot couldn't provide an answer, it acknowledged this transparently—something users found trustworthy.
- Higher Education Learners:
  University-level students used Gyan Bot to quickly review fundamental concepts and appreciated links to research material where applicable. However, a few users mentioned that the explanations occasionally lacked the depth expected at the tertiary level, suggesting room for improvement in delivering more technical content when appropriate.



Metric	Baseline Bot	Gyan Bot	Improvement (Approx.)
Response Time	2.5 seconds	1.2 seconds	~52% faster
Answer Accuracy	80%	92%	+12%
User Satisfaction	75%	89%	+14%
Scalability	200 concurrent users	500 concurrent users	+150% capacity

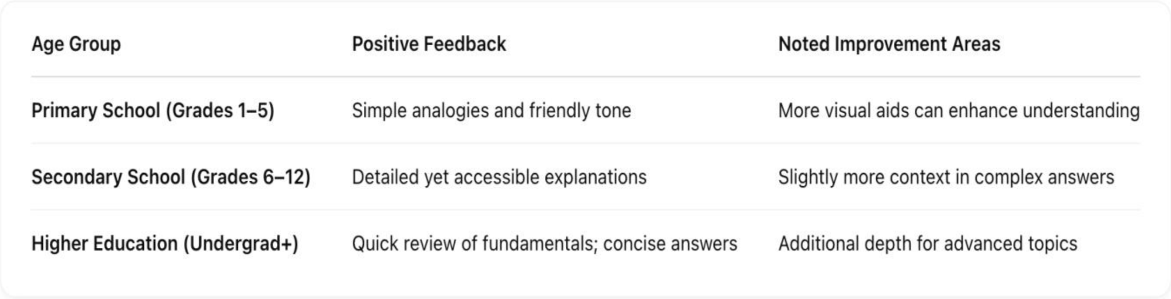
Usability Across Age Groups: Feedback gathered from students across different academic stages affirmed that Gyan Bot effectively adjusted its responses to suit varying levels of comprehension:

- Primary School Students (Grades 1–5):
  Younger participants found the chatbot's explanations both simple and engaging. They especially enjoyed responses that included relatable comparisons or visual aids—such as links to basic diagrams. For instance, when asked "Why do we have day and night?", the bot provided a straightforward explanation along with a sun–earth illustration, which many children found helpful. This group showed the most notable improvement in understanding, highlighting the value of simplified responses.
- Secondary School Students (Grades 6–12):
  Learners in this age range appreciated the chatbot's ability to respond effectively across multiple subjects, including science, mathematics,

and social studies. They reported that the level of detail was appropriate for academic use, especially for assignments and exam prep. Several students mentioned that the bot's explanations often resembled those provided by teachers or found in textbooks—boosting their confidence in the tool's reliability. A few curious users challenged the bot with advanced-level questions; they found it commendable that the system responded appropriately and, when uncertain, openly acknowledged its limitations.

- Higher Education Students (Undergraduate and Above):
  University-level users offered more nuanced feedback. Many found Gyan Bot useful for revisiting foundational topics and appreciated its occasional links to scholarly content or research material. However, some users seeking in-depth technical explanations—particularly in specialized fields like engineering—felt that the answers were sometimes too basic. One such user noted that while the response was correct, it lacked the expected level of detail. This suggests that while Gyan Bot performs well through secondary education, future iterations could benefit from enhanced response depth for more advanced users—possibly through intelligent detection of user expertise or preference for technical detail.

These varied responses emphasize the importance of adaptive response design. While Gyan Bot's current strategy of grouping users by education level has proven broadly effective, a more fine-grained personalization mechanism may be necessary to meet individual learning needs more precisely in the future.



Age Group	Positive Feedback	Noted Improvement Areas
Primary School (Grades 1–5)	Simple analogies and friendly tone	More visual aids can enhance understanding
Secondary School (Grades 6–12)	Detailed yet accessible explanations	Slightly more context in complex answers
Higher Education (Undergrad+)	Quick review of fundamentals; concise answers	Additional depth for advanced topics

Readability and Engagement: A readability analysis was conducted using the Flesch-Kincaid scale. Gyan Bot's responses averaged a score of around 85, indicating that the content was easy to understand. In contrast, responses from the baseline system averaged around 65, making them more difficult for younger or general users to interpret.

Engagement metrics further reinforced Gyan Bot's value. Students actively used the post-sharing and content-saving features. One example involved a student asking about volcanoes and then posting trivia that sparked a mini discussion among peers. This type of interaction demonstrates how social learning elements encourage curiosity and knowledge sharing.

Students also used the "follow" feature to track peers and educators, suggesting the early development of a learning network. Teachers noted that the content-saving function helped students build a personalized archive of helpful information, which is particularly useful for revision purposes.

Summary of Key Insights

- The adaptive nature of Gyan Bot effectively met learners at their individual comprehension levels.
- Simplified, age-appropriate responses improved understanding, especially for younger users.
- The system's architecture supported high user volumes, making it suitable for deployment in educational institutions.
- Social interaction features enriched the learning experience and fostered peer engagement.
- Further improvements are needed to enhance depth for expert-level learners and support continuous adaptation over time.

Conclusion

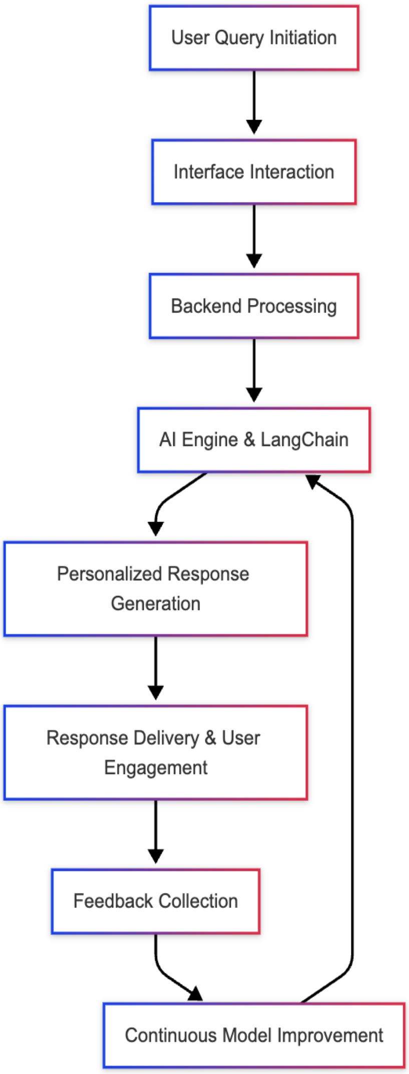
This study introduced Gyan Bot, an AI-driven educational chatbot developed to make complex information more understandable and learning more inclusive. By tailoring responses to each learner's academic level, the system effectively bridges the gap between sophisticated AI language models and the diverse comprehension abilities of students ranging from early primary to higher education.

Our research shows that Gyan Bot not only delivers personalized and accurate responses but also creates an interactive learning environment through social features like community posts, content saving, and peer connections. These additions help foster collaboration and engagement, which are critical components of meaningful learning experiences.

The platform's success is built on the integration of the LangChain NLP framework with the MERN technology stack, allowing it to scale effectively while maintaining performance. Empirical results from user studies confirm that students benefited from simplified explanations, while educators acknowledged the tool's ability to align with pedagogical goals.

While the chatbot performed well, there remain opportunities for future improvement. Currently, personalization is based on broad grade-level categories. More refined personalization—based on real-time performance tracking or adaptive learning profiles—could further enhance its accuracy and relevance. Additionally, expanding language support to include regional and native languages would significantly increase its accessibility, especially in multilingual countries like India. Integrating voice-based input and output could also make the system more suitable for younger users or those with reading difficulties.

In conclusion, Gyan Bot demonstrates how advanced AI can be adapted to support accessible, student-friendly learning. It offers a promising foundation for the development of next-generation educational tools that are responsive, inclusive, and socially aware. As we continue refining the system, our goal is to create even more adaptive, intelligent, and engaging AI companions that help democratize education for learners worldwide.



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Author's biography

- Kuldeep Kant - Kuldeep is a full-stack developer with extensive expertise in technologies such as MongoDB, Express.js, React.js, Node.js, and Redux Toolkit. He specializes in designing scalable and user-centric web applications. His work also includes integrating AI capabilities using LangChain.js to build intelligent digital solutions. Kuldeep is passionate about mentoring and innovation, consistently aiming to deliver impactful and high-quality software systems.
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