



Adaptive AI Tutor with Tailored NLP for Personalized Learning

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KEYWORDS	ABSTRACT
AI Tutor, Personalized Learning, Generative Models, Adaptive Learning, Real-Time Feedback, Interactive Problem-Solving, Root Cause Analysis, Brainstorming.	The Adaptive AI Tutor is an intelligent, personalized learning system designed to enhance student understanding through real-time interaction and customization. Built using Streamlit, Large Language Models (LLMs), and conversational memory, the system adapts its teaching style based on the learner's subject, skill level (Beginner, Intermediate, Advanced), and preferred explanation style (Conceptual, Mathematical, or Code-first). The platform consists of three main modules: Tutor Chat, Quiz Room, and an interactive Code Sandbox. The Tutor Chat enables students to ask questions and receive context-aware responses using conversational memory for continuity. The Quiz Room dynamically generates topic-specific quizzes and evaluates user answers with scoring and feedback. The Code Sandbox allows learners to edit and execute Python code directly within the application, promoting hands-on practice. By leveraging advanced language models and adaptive prompting techniques, the system delivers customized explanations, performance evaluation, and constructive feedback. This project aims to bridge the gap between traditional e-learning and personalized mentorship by providing an interactive, AI-driven tutor that supports self-paced and skill-based learning. The Adaptive AI Tutor improves engagement, strengthens conceptual clarity, and fosters independent problem-solving, making it a scalable solution for modern digital education.

1. INTRODUCTION

1.1. Brief Information

The rapid advancement of digital technologies has transformed the landscape of education, shifting from traditional classroom-based learning to flexible and

technology-driven e learning systems. However, most existing platforms still follow a one-size-fits-all approach, delivering the same content to all learners regardless of their individual abilities, learning pace, or preferences. This limitation often results in reduced

engagement, lack of conceptual clarity, and inefficient learning outcomes. To address these challenges, Artificial Intelligence (AI) and Natural Language Processing (NLP) have emerged as powerful tools for enabling personalized and adaptive learning experiences. AI-driven systems can analyze user behavior, understand context, and generate dynamic responses, making learning more interactive and tailored to individual needs. In particular, Large Language Models (LLMs) have demonstrated remarkable capabilities in understanding complex queries, generating human-like explanations, and supporting real time interaction.

The proposed project, Adaptive AI Tutor with Tailored NLP for Personalized Learning, introduces an intelligent tutoring system that adapts its teaching style based on the learner's subject, skill level (Beginner, Intermediate,

Advanced), and preferred explanation style (Conceptual, Mathematical, or Code-first). Unlike conventional systems, this platform provides context-aware responses using conversational memory, ensuring continuity and coherence in learning.

The system is designed with three key modules: Tutor Chat, Quiz Room, and Code Sandbox. The Tutor Chat module enables interactive learning through question-answer conversations, the Quiz Room dynamically generates and evaluates quizzes to assess understanding, and the Code Sandbox allows users to practice programming in a real-time execution environment. This integration creates a comprehensive learning ecosystem that combines theory, practice, and assessment.

1.2. Purpose

The purpose of the project Adaptive AI Tutor with Tailored NLP for Personalized Learning is to develop an intelligent educational system that provides personalized and interactive learning experiences using Artificial Intelligence and Natural Language Processing. The project aims to overcome the limitations of traditional e-learning platforms by adapting teaching methods based on the learner's subject, skill level, and preferred explanation style. It enables real-time interaction through a conversational interface, allowing students to ask questions and receive context-aware responses. Additionally, the system integrates learning, assessment, and practical implementation through

modules like Tutor Chat, Quiz Room, and Code Sandbox. By providing customized explanations, instant feedback, and hands-on practice, the project enhances student engagement, improves conceptual understanding, and supports self-paced learning, making it a modern and scalable solution for digital education.

A. 1.3. Motivation

The motivation behind this project is to overcome the limitations of traditional e-learning systems that do not adapt to individual student needs. Many learners struggle due to lack of personalized guidance, real-time interaction, and practical learning support. This project aims to use Artificial Intelligence and NLP to create an adaptive, interactive tutor that provides customized explanations, instant feedback, and hands-on practice, making learning more effective, engaging, and accessible.

1.4. Problem Statement

The problem addressed by this project is the limitation of traditional and existing e-learning systems, which follow a one-size-fits-all approach and fail to provide personalized learning experiences. These systems deliver the same content to all learners without considering their skill level, learning pace, or preferred learning style, resulting in poor engagement and limited understanding. Additionally, most platforms lack real-time interaction, context-aware responses, and detailed feedback, making it difficult for students to clarify doubts effectively. They also do not integrate theory, assessment, and practical coding in a single environment, forcing users to switch between multiple tools. Hence, there is a need for an intelligent system that can provide adaptive, interactive, and personalized learning with real-time feedback and practical support.

2. LITERATURE SURVEY

2.1. Introduction

The literature review explores existing research in intelligent educational systems, covering areas such as Intelligent Tutoring Systems (ITS), Artificial Intelligence in education, Natural Language Processing (NLP), conversational AI, and adaptive learning technologies. It highlights the evolution from rule-based methods to AI-driven models that support personalization, automation, and interactive learning, further enhanced by Large Language Models (LLMs) for human-like

responses and open-ended query handling. By comparing traditional and modern approaches, this chapter identifies key limitations such as lack of personalization, limited interactivity, and absence of practical learning integration, emphasizing the need for an adaptive AI tutor that combines conversational learning, real time feedback, quiz evaluation, and coding practice in a unified system.

2.2. AI-Based Personalized Learning Platforms

AI-based personalized learning platforms use machine learning algorithms to tailor educational content based on user behavior, performance, and preferences. These systems analyze data such as quiz scores, response time, and interaction patterns to adjust the difficulty level and recommend suitable learning materials. 9 Such platforms improve student engagement by providing customized learning paths and adaptive content delivery. They also enable continuous monitoring of learner progress, helping identify strengths and weaknesses. However, many of these systems depend on structured datasets and predefined learning paths, which limits their ability to handle dynamic queries and real-time interaction. They often lack deep conversational capabilities, making them less interactive compared to modern AI tutoring systems.

2.3. Conversational Ai And Chatbots In Education

Conversational AI systems and chatbots have significantly improved user interaction in educational platforms by enabling natural language communication. These systems allow learners to ask questions and receive instant responses, making learning more interactive and accessible. Early educational chatbots were rule-based and relied on predefined responses, which limited their ability to handle complex queries. Modern chatbots, powered by advanced AI models, can understand context, generate detailed explanations, and support open-ended conversations. Despite these advancements, many chatbot systems lack integration with structured learning modules such as quizzes, evaluation systems, and coding environments. This limits their effectiveness as complete educational solutions.

2.4. NLP Techniques For Learning Systems

Natural Language Processing (NLP) plays a vital role in enabling intelligent educational systems to understand

and process human language. Basic NLP techniques include tokenization, part-of-speech tagging, and text classification, which help in analyzing user input. With the development of transformer-based models, NLP systems have become more powerful, enabling context-aware responses and improved language understanding. These models can handle complex queries, generate explanations, and even produce code. In educational systems, NLP allows for interactive learning, where users can communicate naturally with the system. However, implementing NLP effectively requires careful design to ensure accuracy, relevance, and clarity in responses.

2.5. Limitations Of Existing Systems And Research Gap

Despite significant advancements in AI and educational technologies, existing systems still face several limitations: Lack of dynamic personalization based on user learning style and Limited real-time feedback and evaluation mechanisms and Absence of integrated coding environments for practical learning. Dependence on structured datasets and predefined rules. Lack of unified systems combining tutoring, assessment, and practice Most systems provide only partial solutions, such as content delivery, quiz evaluation, or conversational interaction, but fail to integrate all these features into a single platform. This creates a clear research gap in developing a comprehensive, adaptive, and interactive learning system that can provide personalized tutoring, real-time feedback, and practical learning support.

3. PROPOSED SYSTEM

The proposed system, Adaptive AI Tutor with Tailored NLP for Personalized Learning, provides an intelligent, interactive, and personalized learning environment by integrating Artificial Intelligence, Natural Language Processing (NLP), and Large Language Models (LLMs). Unlike traditional systems with static content, it dynamically adapts teaching based on the learner's needs. Users can select parameters such as subject, skill level (Beginner, Intermediate, Advanced), and explanation style (Conceptual, Mathematical, or Code-first). Based on these inputs, the system generates customized explanations suited to the learner's understanding level.

System Architecture

The system architecture of the Adaptive AI Tutor is designed as a modular framework consisting of a user interface, backend server, AI engine, and database. The user interacts through a web-based interface by entering queries and selecting preferences such as subject, difficulty level, and learning style. These inputs are processed by the backend, which manages requests and communicates with the AI engine. The AI engine uses Natural Language Processing and Large Language Models to analyze queries and generate personalized responses. The system also includes modules like Tutor Chat, Quiz Room, and Code Sandbox for learning, assessment, and practice. A database stores user data and learning history to support personalization. The final output is then displayed to the user through the interface, ensuring an interactive and adaptive learning experience.

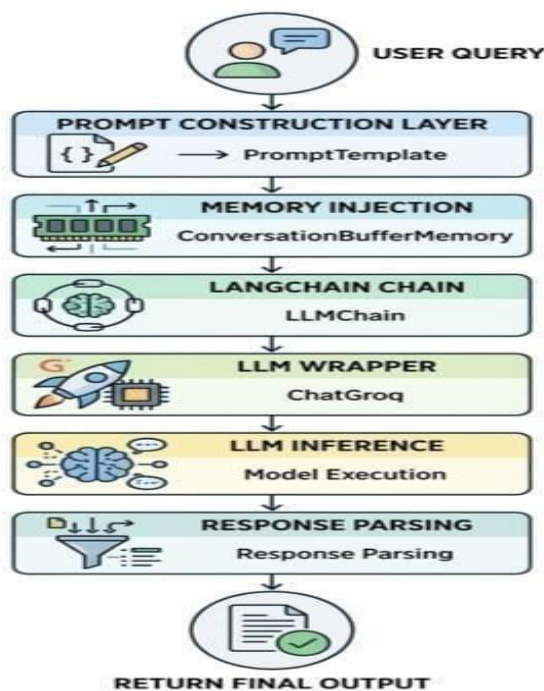


Fig 1: System Architecture (AI-Based Real-Time Suspicious Moment Detection)

Proposed Workflow

The proposed workflow of the Adaptive AI Tutor begins with the user entering a query and selecting preferences such as subject, difficulty level, and learning style through the frontend interface. The input is then sent to the backend server, where it is processed and forwarded to the AI engine. The system performs NLP preprocessing to clean and structure the input before passing it to the Large Language Model for understanding and response generation. The generated

response is then refined through a personalization layer, which tailors the output based on user preferences and past interactions stored in the database. Finally, the processed and formatted response is sent back to the frontend and displayed to the user. Additionally, the workflow integrates modules like Tutor Chat, Quiz Room, and Code Sandbox to provide learning, assessment, and practical experience in a unified system.

Advantages of Proposed System

- **Personalization:** Provides personalized learning based on user level and preferences.
- **Real-Time Interaction:** Enables real-time interaction with instant responses.
- **Flexibility:** Supports self-paced learning anytime, anywhere and Reduces dependency on traditional classroom methods.
- **User Engagement:** Improves student engagement and interest and Makes learning more interactive and dynamic.
- **Knowledge Enhancement:** Enhances concept clarity and understanding and Improves knowledge retention and learning efficiency
- **Adaptability:** Supports adaptive teaching methods for better understanding and Adjusts content based on learning style and progress

4. RESULTS

The results and discussion chapter presents the outcomes obtained from the implementation of the adaptive ai tutor system and analyzes its overall performance. it evaluates how effectively the system generates responses, conducts quizzes, and executes code while ensuring a smooth user experience. this chapter also compares the system with existing solutions, highlights its strengths and limitations, and examines how well it meets user requirements. overall, it provides a clear understanding of the system's effectiveness and its impact on personalized learning.

4.1. Experimental Setup

The experimental setup of the proposed system involves implementing the Adaptive AI Tutor on a web-based platform using a frontend interface for user interaction and a backend server for processing requests. The system is integrated with a Large Language Model to generate responses based on user queries. Users provide inputs such as subject, difficulty level, and learning

style, which are processed using NLP techniques. The system is tested using different types of queries across multiple domains to evaluate its performance in terms of accuracy, response relevance, and personalization.

4.2. Results of System Evaluation

The results of the system evaluation demonstrate that the Adaptive AI Tutor performs effectively in delivering personalized and relevant learning experiences. The system was tested with various user queries across different subjects and difficulty levels, and it consistently generated accurate, context-aware responses.

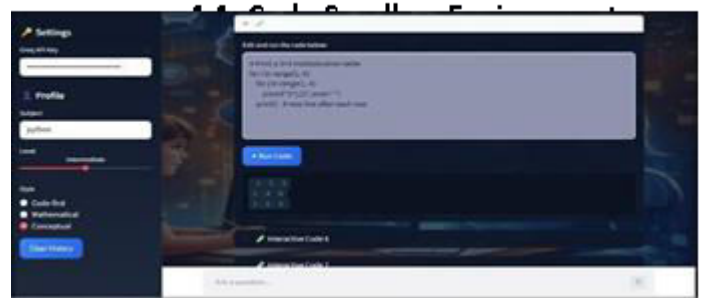


Fig 4 AI-Assisted Interactive Python Code Learning System

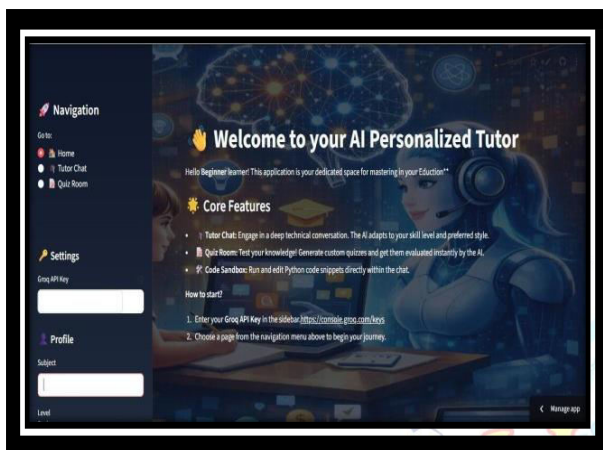


Fig 2: Results of Object Detection – Crowd

4.3. Welcome Dashboard

The dashboard serves as the main entry point of the system, providing users with an overview of the AI Personalized Tutor. It greets the user and introduces the platform as a dedicated space for mastering concepts through intelligent assistance. It ensures a user-friendly and engaging starting experience.

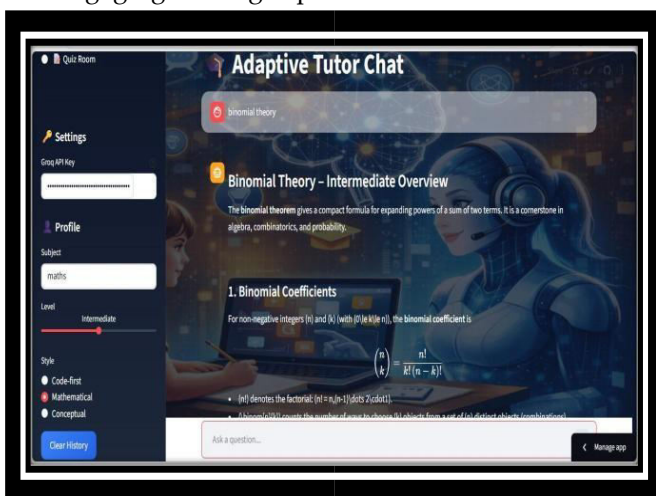


Fig 3 Style: Mathematical for Interactive Binomial Theory Learning with an Adaptive AI Tutor



Fig 5. AI-Driven Adaptive Quiz Generation & Assessment Module

5. CONCLUSION

The Adaptive AI Tutor with Tailored NLP for Personalized Learning successfully demonstrates how Artificial Intelligence can be used to enhance modern education. The system integrates technologies such as Large Language Models, Natural Language Processing, and conversational memory to provide a personalized and interactive learning experience. The project effectively combines three main functionalities: Tutor Chat, Quiz Generation, and Code Execution Sandbox. The Tutor Chat module enables users to ask questions and receive context-aware responses tailored to their subject, skill level, and preferred explanation style. The Quiz module dynamically generates questions and evaluates user answers with meaningful feedback, helping users assess their understanding. The Code Sandbox allows users to execute Python code, promoting practical learning and experimentation. The system is implemented using Python, Streamlit, Lang Chain, and the Groq API, ensuring smooth interaction between the user interface and backend logic. The modular design makes the system scalable, maintainable, and efficient. Overall, the project achieves its objective of providing a personalized AI-based

tutoring system that improves learning engagement, enhances conceptual understanding, and supports self-paced learning. It serves as a strong example of how AI can bridge the gap between traditional learning and intelligent tutoring systems.

6. FUTURE SCOPE

The future scope of the Adaptive AI Tutor system includes enhancing its capabilities by integrating advanced AI models for more accurate and human-like interactions. The system can be expanded to support multiple languages, making it accessible to a wider range of users. Additional features such as voice-based interaction, real-time doubt solving through speech, and integration with virtual or augmented reality can further improve the learning experience. The platform can also incorporate advanced analytics to track student performance in detail and provide better recommendations. Furthermore, it can be deployed on mobile applications and integrated with educational institutions to create a more scalable and widely accessible personalized learning solution. Additionally, emerging technologies such as Virtual Reality (VR) and Augmented Reality (AR) can be incorporated to provide immersive and interactive learning experiences, especially for complex subjects. The platform can also include advanced analytics and learning dashboards to track user progress, identify weak areas, and provide intelligent recommendations. Future improvements may involve collaborative learning features, where multiple users can interact and learn together, as well as teacher integration for monitoring and guidance. The system can be deployed as a mobile application and integrated with existing educational platforms or institutions to increase scalability and accessibility. Furthermore, continuous learning mechanisms can be added so that the system improves over time based on user interactions, making it more adaptive

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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