AI-Powered Personalised Tutoring System

Team members:

- **Sanskruti Gogirwar (Team leader)**
  Led the project, implemented adaptive learning logic, designed the frontend using Flask, and integrated course recommendation features.

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  Developed the FastAPI backend, handled chatbot data feeding and training, and managed assessment evaluation logic.

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  Integrated AI models, implemented answer evaluation logic, and optimized model performance.

Guide:

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Abstract

The demand for personalized education has increased significantly with the rise of online learning. However, traditional digital learning platforms fail to cater to individual learning paces and preferences, often leading to disengagement and ineffective knowledge retention. Our AI-powered tutoring system aims to bridge this gap by utilizing Artificial Intelligence (AI), Machine Learning (ML), and Natural Language Processing (NLP) to create an interactive and adaptive learning environment.

This system dynamically adjusts course content based on a learner's performance, provides intelligent assessments, delivers real-time feedback, and recommends personalized learning paths. With AI-powered chatbots for 24/7 assistance and automated evaluations, it ensures an efficient and engaging learning experience. Furthermore, the platform is built with scalability in mind, allowing it to serve a vast number of users without compromising performance.

1. Introduction

1.1 Background

Online learning has revolutionized education, making knowledge accessible to anyone with an internet connection. However, the existing e-learning platforms lack personalization, often offering static course structures that do not accommodate different learning styles, strengths, and weaknesses. Moreover, assessments are generic, and learners receive minimal interactive support to guide them through their challenges.

1.2 Objective

Our AI-powered tutoring system seeks to overcome these limitations by:

- Creating adaptive learning pathways that adjust in real time.
- Providing personalized recommendations based on student performance.
- Implementing intelligent assessments that evolve with the learner's progress.
- Enhancing engagement with an AI-powered chatbot for interactive support.
- Optimizing scalability and efficiency to handle a large number of learners seamlessly.

By integrating AI-driven automation, this system aims to offer an immersive and efficient educational experience while reducing manual intervention.

1.3 Overview

The AI-powered tutoring system is an intelligent, automated, and scalable learning platform designed to enhance knowledge acquisition. The key components include:

Key Features:

- AI Chatbot Assistance: Provides instant help to learners, answering queries using NLP.
- Adaptive Learning: Modifies course content dynamically based on user performance.

- AI-Driven Assessments: Generates personalized questions and evaluates responses.
- Personalized Learning Paths: Uses ML to recommend topics for further improvement.
- Scalability: Optimized architecture ensures seamless operation for a large user base.

This system fosters engagement, efficiency, and effectiveness in digital learning, helping learners achieve better outcomes with minimal human intervention.

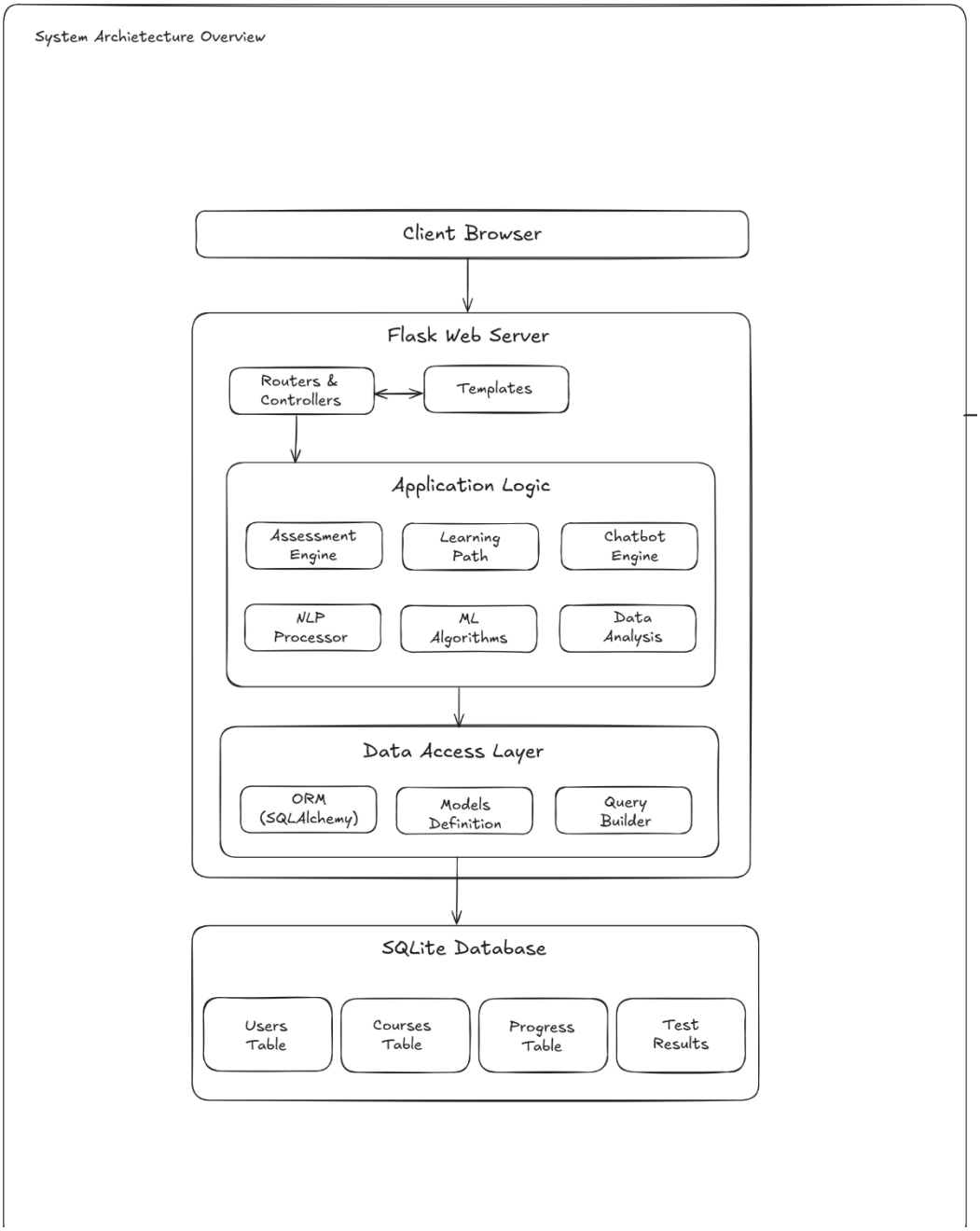


Fig 1.1 System Architecture Overview

1.4 Problem Solved

Conventional learning systems struggle to cater to individual learning styles, leading to gaps in knowledge retention and user disengagement. Students often waste time revisiting topics they already know or struggle to catch up with difficult content without personalized support. Our system addresses this by using initial assessments to identify each learner's starting level and adaptively guiding them through the content. It ensures mastery by enforcing a pass threshold and uses AI to provide additional support for struggling learners.

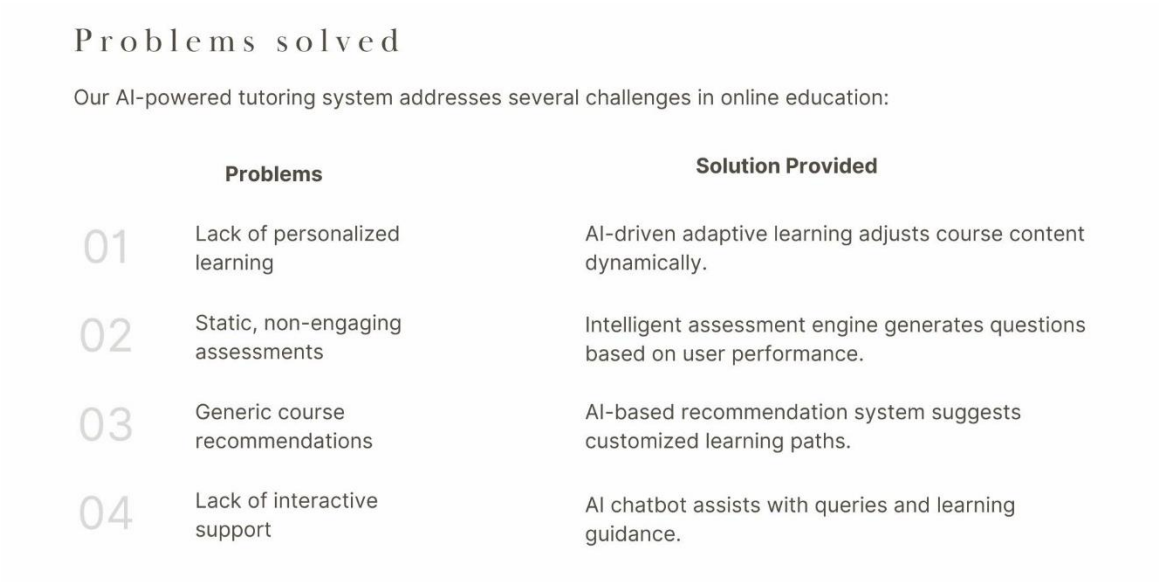


Fig 1.2 Problems solved

2. Technologies Used

2.1 Frontend

The frontend interface is built using HTML, CSS, and JavaScript, ensuring a responsive, interactive, and user-friendly experience. Jinja2, a powerful templating engine that comes with Flask, is used to render dynamic content, pass server-side data into web pages, and manage UI components efficiently. This combination allows users to seamlessly interact with the system and receive real-time feedback based on their actions.

2.2 Backend

The backend of the system is developed using Flask, a lightweight and scalable web framework in Python that allows rapid development of web applications with minimal overhead. It serves as the foundation for routing, session management, and integration with machine learning models. For database management, SQLite is used—a lightweight, file-based relational database system ideal for quick development and local storage. It simplifies deployment and reduces configuration needs while ensuring reliable data persistence. Flask-Login is integrated for handling user sessions, keeping track of logged-in users, and managing secure user authentication processes.

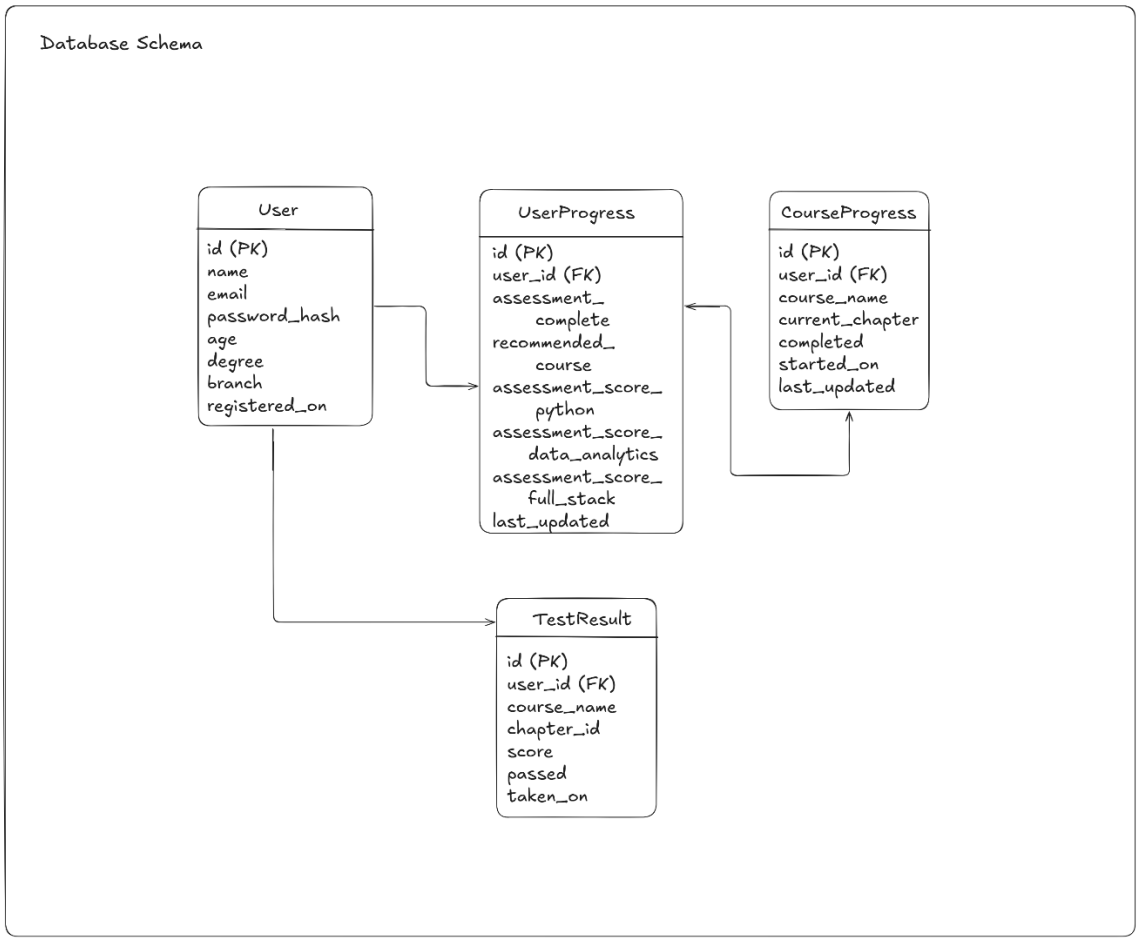


Fig 2.1 Database Schema

2.3 AI/ML Components

The system leverages various AI and machine learning techniques to deliver a smart and personalized learning experience. One of the core components is Natural Language Processing (NLP), which powers the AI chatbot that interacts with users in real time. The chatbot provides on-demand assistance, answers queries, and suggests relevant resources, making learning more interactive and user-friendly. This functionality is enabled through a chatbot API that integrates NLP models via RESTful endpoints. It sends user queries to the backend and receives intelligent, context-aware responses to maintain a seamless conversation flow.

In addition to chatbot interaction, NLP techniques are used for automated question generation, which helps create dynamic assessments tailored to the user's learning level. This ensures a consistent evaluation and personalized feedback mechanism.

The system also includes Machine Learning (ML) algorithms for personalized course recommendations. By analysing user performance, preferences, and learning behaviours, the system recommends modules and resources that align with each learner's needs. These recommendations improve over time as the system continues to learn from user interactions, ensuring increasingly accurate and helpful suggestions.

Together, these AI and ML components form the intelligence layer of the platform, enabling adaptive learning, personalized feedback, and enhanced user engagement through natural conversation and smart decision-making.

2.4 Data Processing

To handle and analyse user data effectively, libraries such as Pandas, NumPy, and Scikit-learn are used. Pandas simplifies data manipulation and cleaning, NumPy provides efficient numerical operations, and Scikit-learn offers robust ML algorithms and tools for building and training models for recommendations, classification, and regression.

2.5 Performance Optimization

The platform is designed for high performance and scalability. Techniques like AI-driven load balancing ensure that server load is evenly distributed, avoiding bottlenecks. Optimized database queries enhance data retrieval times and ensure efficient backend operations, especially when dealing with large user bases. Intelligent caching mechanisms reduce repeated computations and accelerate content delivery, resulting in a smoother user experience even under high usage.

3. Functionalities

3.1 AI-Based Initial Assessment to Define Learning Paths

The system begins with an AI-powered diagnostic test that assesses a learner's current knowledge level. Based on the test results, the platform automatically defines a personalized learning path. This ensures that learners start at the appropriate module — skipping what they already know and focusing on areas that need improvement.

3.2 Adaptive Learning with Dynamic Module Unlocking

The learning experience is adaptive in nature. After each module, a learner takes a short test. If they score 60% or above, the next module is unlocked. If they fail, they have three attempts before the system redirects them to the previous module for review. This guarantees concept clarity and prevents learners from advancing without mastery.

3.3 Personalized Course and Material Recommendations

The system analyses user performance, interaction patterns, and learning behaviours to suggest the most relevant study materials, modules, or even full-length courses. These recommendations evolve as the learner progresses, becoming more accurate and targeted over time.

3.4 Real-Time AI Chatbot for Learning Support

The integrated AI-powered chatbot provides instant assistance to learners. It can clarify doubts, explain concepts, suggest resources, and even guide users through their learning path. The chatbot uses Natural Language Processing (NLP) and is connected through an API that enables real-time query handling and intelligent response generation.

3.5 Performance Tracking and Analytics

The system continuously tracks the learner's progress and performance across modules. Visual dashboards and analytics tools present data such as test scores, time spent, improvement trends, and weak areas. These insights help both learners and instructors monitor learning outcomes and adjust strategies accordingly.

3.6 Module-Level Testing with Auto-Navigation on Failure

Every module includes an embedded quiz to test comprehension. If a learner fails to achieve the passing score after three tries, the system auto-navigates them back to a previous module. This ensures that foundational knowledge is strong before progressing to more complex topics, reinforcing effective learning.

3.7 Skip or Revisit Modules Based on Performance

Learners who perform exceptionally in the initial assessment or ongoing module tests can skip over content they've already mastered. Likewise, those struggling with certain topics are encouraged to revisit earlier modules. This adaptive skip-and-revisit mechanism personalizes the learning journey while optimizing time and effort.

3.8 Course Progression Engine Ensuring Learning Continuity

A smart course progression engine ensures smooth navigation across the learning path. It handles module unlocking, failure redirection, re-assessment triggers, and milestone tracking. The engine ensures continuity, reducing user confusion, and enabling learners to stay focused and motivated throughout the journey.

4. Features & Workflow

4.1 Features

4.1.1 Adaptive Learning Pathways

The system starts with an initial assessment to define a personalized learning track. Learners begin at an appropriate module, can skip familiar topics, and are redirected to previous modules if they struggle, ensuring effective learning.

4.1.2 Recommendation System

AI suggests courses, alternative learning paths, and additional study materials based on performance. It provides personalized resources to reinforce understanding and improve retention.

4.1.2 Chatbot Integration

An AI-powered chatbot provides instant query resolution, personalized guidance, and interactive support using NLP. It assists with concept clarification, module navigation, and course recommendations while tracking progress and suggesting remedial actions. This 24/7 virtual assistant enhances engagement and learning efficiency.

4.1.4 Assessment Engine

Each module ends with a test requiring 60% to pass. Learners get three attempts; failure leads to a previous module review. AI monitors progress and adapts learning paths dynamically.

4.2 Workflow

The platform starts with an assessment to understand the learner's proficiency. Based on scores, learners are mapped to different tracks. Those with higher scores can skip basic modules, while beginners start from foundational topics. After each module, a test is conducted. Learners must score 60% to move ahead. If they fail three times, they are taken back to the previous module for reinforcement. An AI engine recommends supplementary content throughout. The chatbot answers questions and guides learners in real time. The platform tracks all interactions and adapts the learning flow accordingly to ensure optimized outcomes.

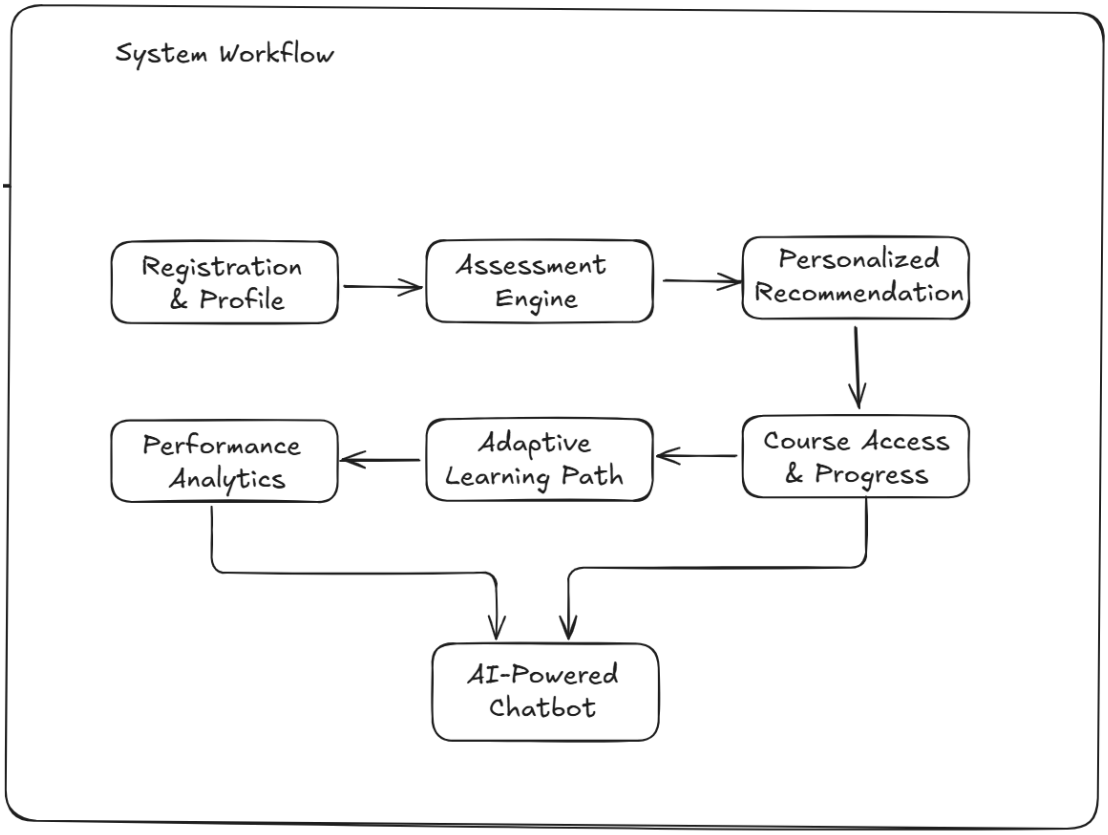


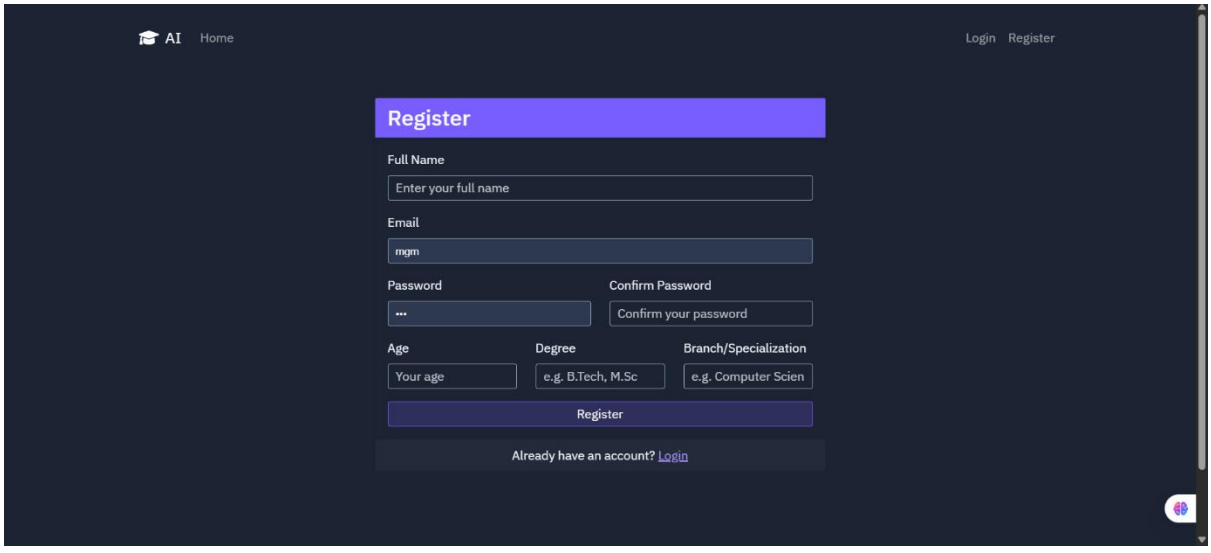
Fig 4.1 System Workflow

5. Output (Project Display)

1. Users land on the home page and click "Get Started" to begin their learning journey with an intuitive onboarding experience.

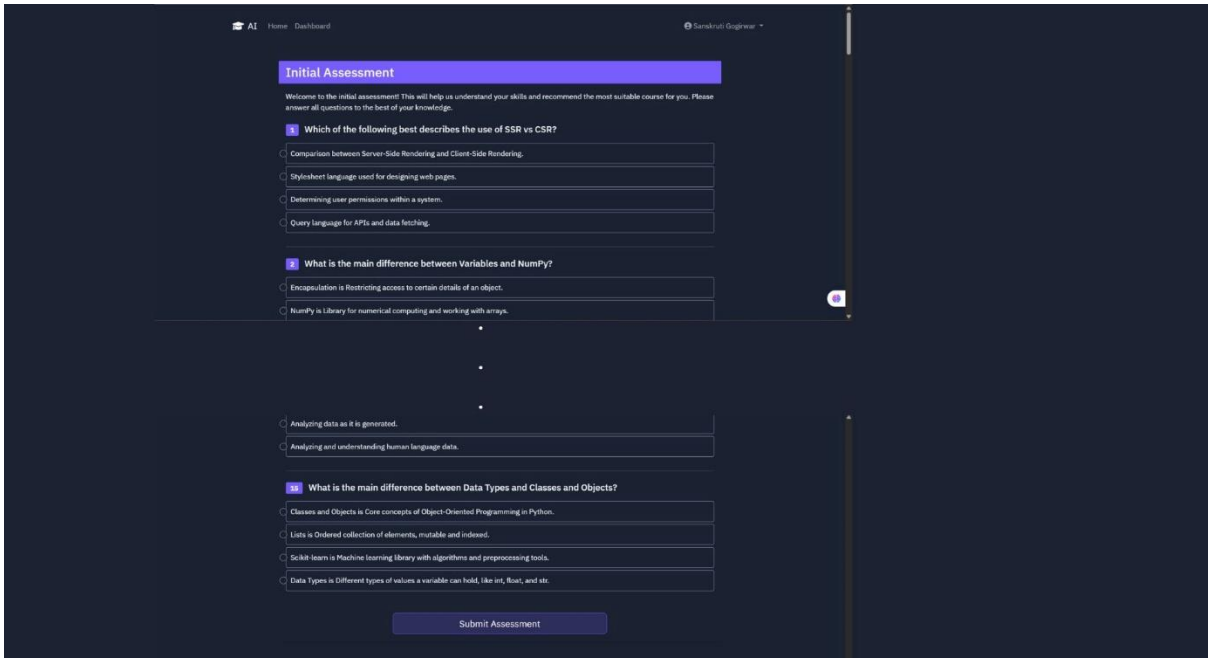
5.1 Home page

2. New users register by creating a profile, while existing users log in to track their progress and receive personalized learning recommendations.



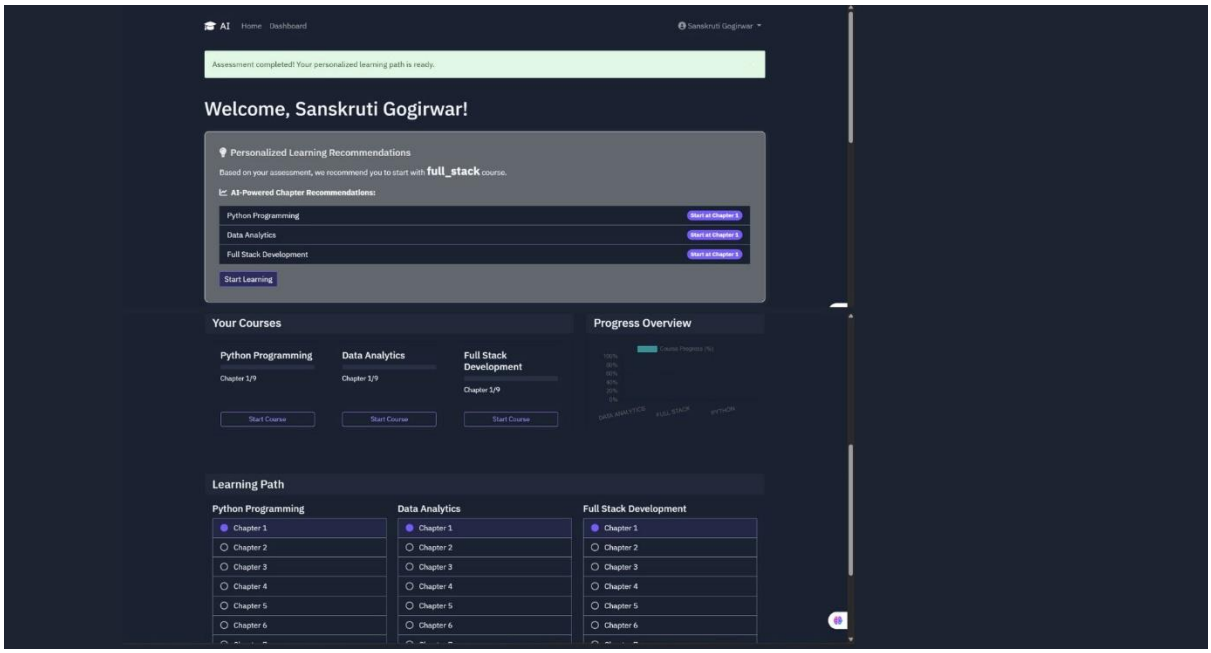
5.2 Login/ register

3. The Assessment Engine evaluates users' knowledge levels, determining their starting module to ensure an optimized learning experience.



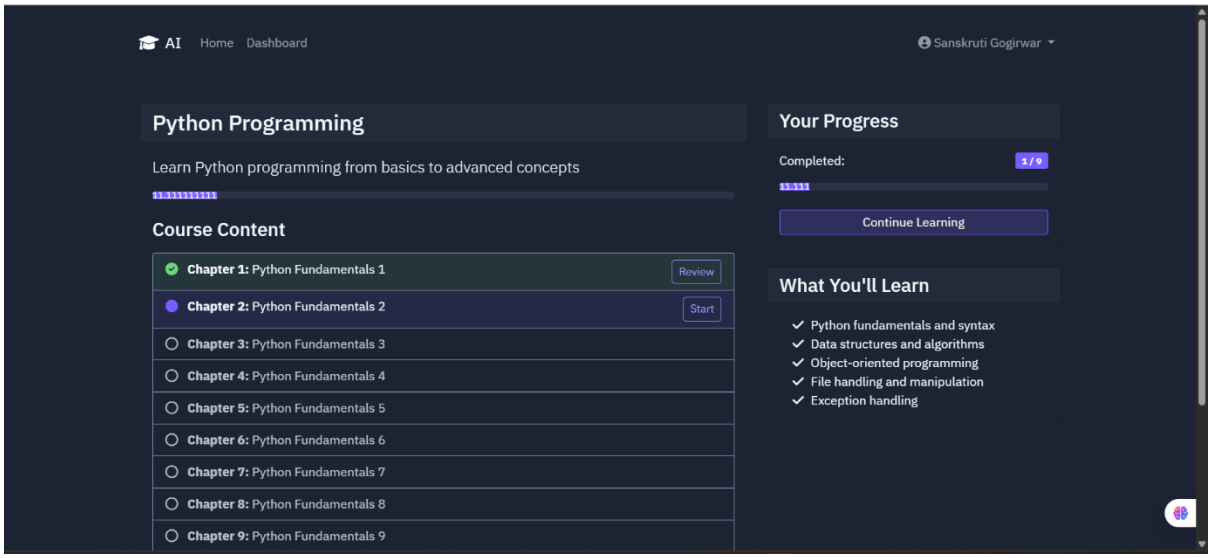
5.3 Initial Assessment

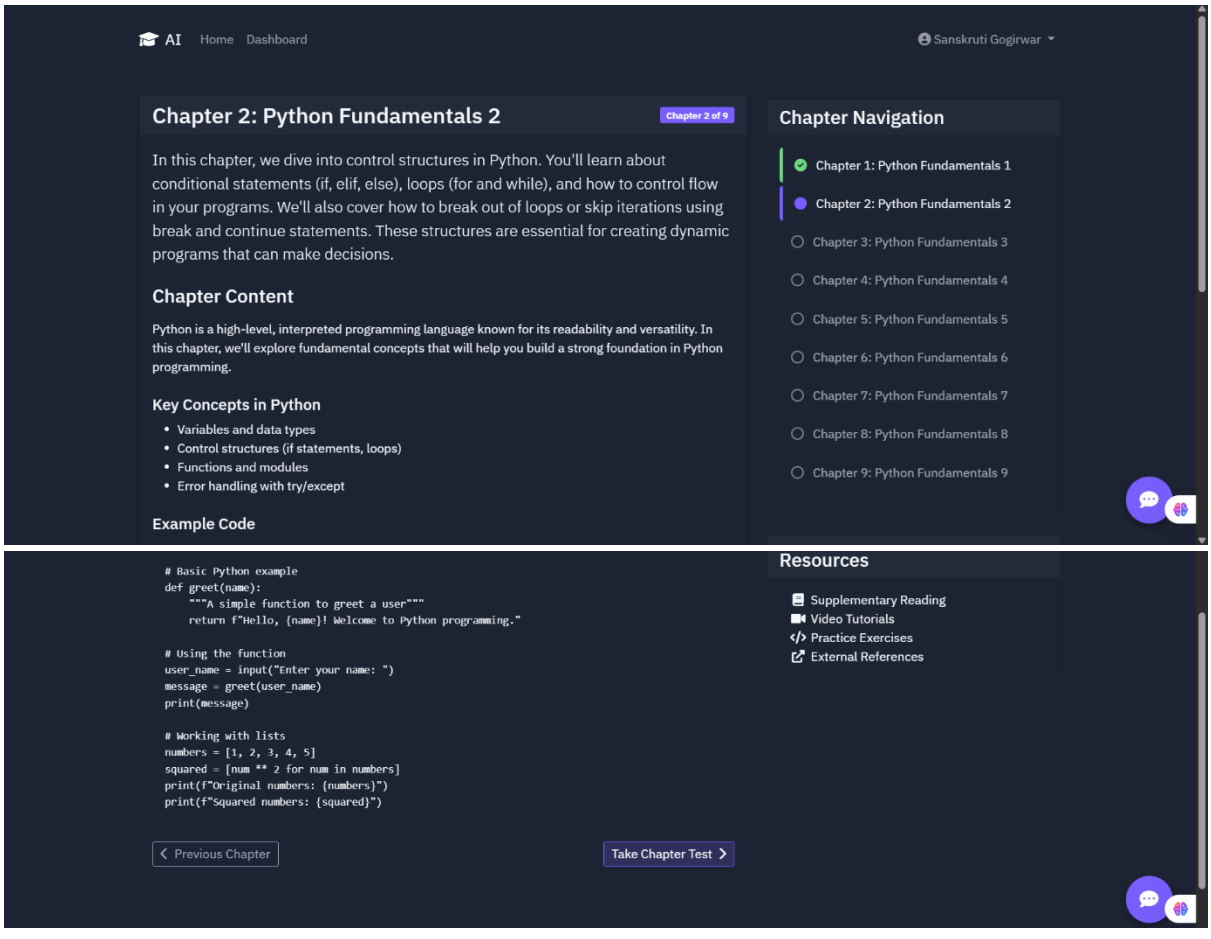
4. After logging in, the user is directed to the dashboard, which displays their assigned learning path. From here, they can select the active module to start learning. Each module includes interactive learning material such as videos, notes, infographics, and reference links tailored to the learner's level and previous performance. A personalized learning path is assigned, adjusting based on progress. Users can skip, revisit, or retry modules, while an AI chatbot assists with queries and performance tracking.



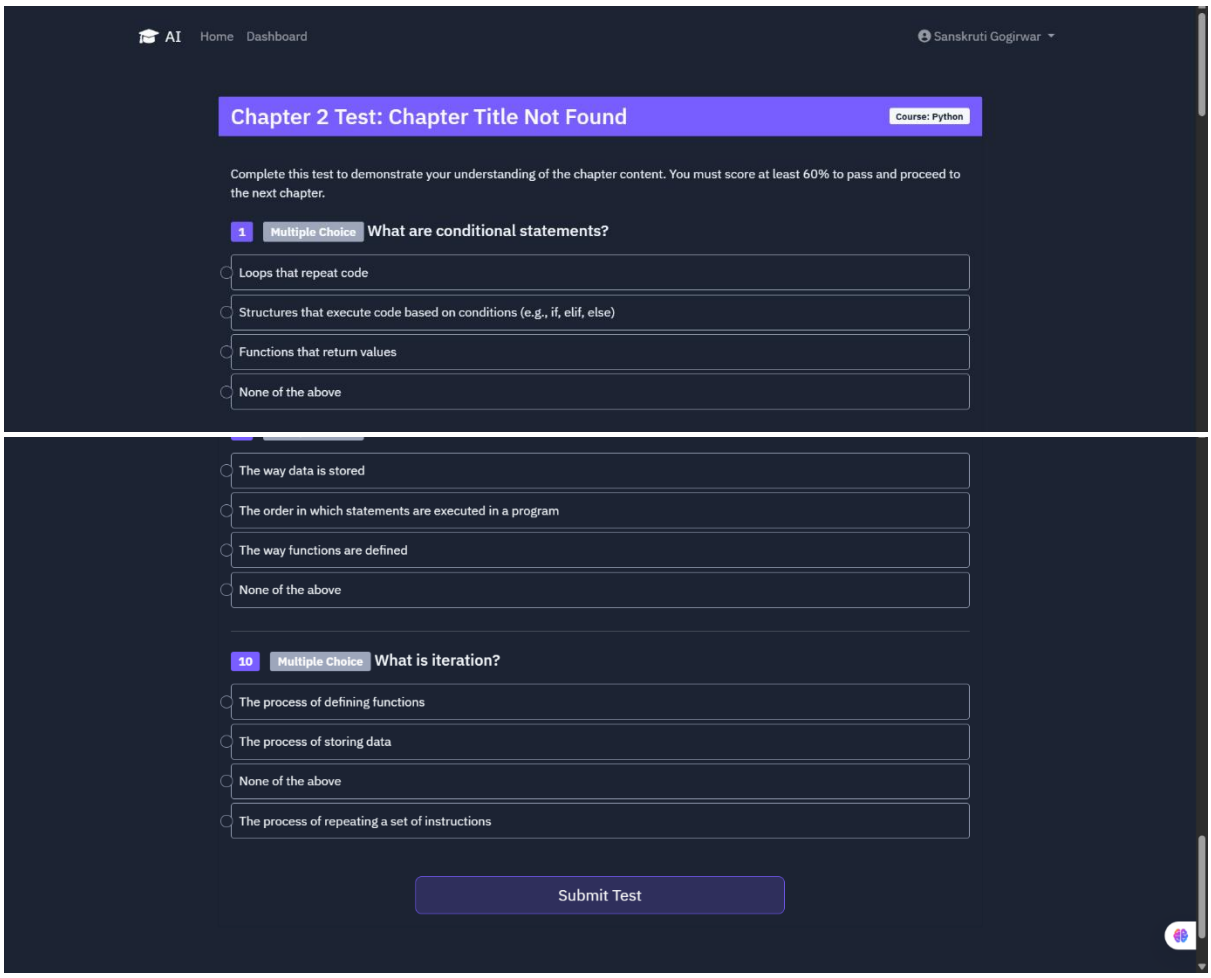
5.4 Dashboard (Progress tracking)

5. Learners can begin their journey by accessing the recommended course materials tailored to their initial assessment. Each module includes a rich mix of content such as notes and interactive resources. These materials are aligned with the learner's current skill level, ensuring relevant and focused learning.





6. Once a learner completes a module, the system automatically launches a dynamic assessment quiz to evaluate their grasp of the material. The questions may be generated using NLP-based AI algorithms to ensure relevance and variety. A minimum score of 60% is required to unlock the next module. After submission, learners receive immediate feedback including correct/incorrect responses, detailed explanations, and performance analytics such as time taken, topic-wise strengths and weaknesses, and overall score. If the learner passes the quiz, the next module becomes available. If they fail, they are given up to three attempts to clear the test. Failing all three attempts redirects the learner to the previous module for revision, ensuring they strengthen their understanding before retrying. The platform also updates the dashboard with real-time analytics and uses the AI-powered recommendation engine to suggest alternative study materials or additional courses based on the learner's performance history.



Conclusion

In conclusion, this AI-powered personalized learning system successfully addresses the limitations of traditional one-size-fits-all education by introducing an adaptive and intelligent learning environment. Through features such as AI-based initial assessment, dynamic learning paths including 3 paths- Python programming, Data Analytics and Full Stack Development, real-time chatbot support, personalized course recommendations, and module-level testing with auto-navigation, the system ensures that each learner receives a tailored experience suited to their knowledge level and pace. The integration of secure technologies, a scalable backend, and efficient performance optimization further strengthens its usability and reliability. By continuously tracking learner performance and adapting the content accordingly, the platform not only enhances knowledge retention but also fosters self-directed learning. This project demonstrates the powerful potential of AI in revolutionizing education, making learning more efficient, inclusive, and future-ready.