International Journal of Technology and Applied Science (IJTAS)
E-ISSN: 2230-9004 ● Website: www.ijtas.com ● Email: editor@ijtas.com

AI Powered Personalized E-Learning Platform

Kajal Pal[1], Yogita Dhote[2], Pushkar Verma[3], Vinayak Bhodekar[4], Dr. Pankaj Singh Sisodiya[5]

Abstract:
This research presents the design and development of an **AI Powered Personalized E-Learning Platform** that focuses on structured learning through roadmap generation, real-time progress tracking, and intelligent chatbot assistance. The platform is designed to support students and educators by providing an interactive and organized digital learning environment. In addition to guided learning, the system allows students to participate in quizzes, interact through a community discussion forum, and receive certificates after successful course completion.
The platform integrates an AI assistant chatbot to answer learner queries instantly and provide guidance during study. A roadmap generation feature creates structured learning paths based on previous learning behavior or user-selected topics and technologies. Progress tracking monitors completed lessons, quiz scores, and learning activity. Community interaction is enabled through a discussion forum that supports communication between students and instructors. Upon completion of a course, learners receive a domain-specific certificate.
Core algorithms are Role-Based Access Control (RBAC), B-Tree indexing, and transformer-based self-attention are used to ensure secure access, efficient data processing, reliable transactions, and intelligent AI interaction. Experimental evaluation shows that the platform improves learner engagement, learning organization, and system efficiency compared to traditional e-learning systems.

Keywords: E-Learning, Artificial Intelligence, MERN Stack, Roadmap Generation, Progress Tracking, Chatbot, Quiz System, Discussion Forum, Certification.

1. INTRODUCTION

Online education has become an essential part of modern learning due to its flexibility and accessibility. However, most existing e-learning platforms mainly provide content delivery without proper guidance or structured learning paths. Students often face difficulty in deciding what to study next, tracking their progress, and getting immediate help when doubts arise. Limited interaction between learners and instructors also reduces engagement.
This research proposes an AI-powered roadmap-based e-learning platform that emphasizes guided and interactive learning. The system generates structured learning roadmaps based on learner performance and also allows custom roadmap creation for selected topics or technologies such as Web Development or Java. An AI assistant chatbot provides real-time doubt-solving support. A quiz module evaluates learner understanding, while a progress tracking system monitors learning activity. A community discussion forum supports interaction and collaborative learning. After successful completion of a course, the system provides a certificate to the learner based on the completed domain.
The system is built using modern web technologies to ensure scalability, usability, and security. By integrating roadmap generation, quizzes, community interaction, and certification, the platform aims to improve learning efficiency and learner motivation.

2. LITERATURE REVIEW:

In the context of this project, several recent surveys and research papers on AI-based e-learning systems have been reviewed to understand their design, technologies, and effectiveness in enhancing digital education. These studies provide insights into how Artificial Intelligence (AI) and Machine Learning

(ML) are being used to personalize learning experiences, track student progress, and improve learner engagement. The reviewed literature forms the foundation for developing this AI Powered Personalized E-Learning Platform, which integrates chatbots, roadmap generation, quizzes, community interaction, certification and progress tracking to create an intelligent and interactive learning environment.

First reference paper discusses **Knowledge Tracing models** that track what students understand and predict their future performance. The authors describe how AI can analyze a student's quiz history and study habits to adjust the learning path in real time. The model helps identify weak areas and recommend suitable materials.

These ideas inspired our project's **progress tracking module**, which records lecture watch time, quiz performance, and progress percentage to personalize learning for every student. [1]
Second paper of research presents the development of a **scalable e-learning system using the MERN stack** MongoDB, Express, React, and Node.js. It emphasizes efficient data handling, a responsive interface, and real-time updates. The paper influenced our project's **technical implementation**, as we also used MERN to ensure flexibility, performance, and easy scalability. [2]

Next paper discusses how AI is transforming education by automating administrative tasks, supporting teachers, and enabling personalized student support. It also predicts that future e-learning systems will fully depend on AI for adaptability and student engagement.This paper guided our **AI integration strategy**, ensuring that personalization, analytics, and automation form the backbone of our system's design. [3]

Fourth review paper explains how **adaptive learning systems** use AI to automatically adjust study content based on learner performance. The authors highlight that personalization increases motivation and learning outcomes compared to static e-learning systems.

This research supports our project's **roadmap generation feature**, the system generates structured learning roadmaps based on learner performance and also allows custom roadmap creation for selected topics or technologies such as Web Development or UI/UX Design.[4]
Next study focuses on the use of **AI chatbots** to assist students in solving doubts instantly. Chatbots can simulate tutor-like conversations, improving learner interaction and satisfaction.

The findings helped design our **AI chatbot module**, which allows students to ask questions and get instant answers, reducing their dependency on teachers for minor doubts. [5]

3. METHODOLOGY

Algorithms Used:

- **Role-Based Access Control (RBAC)**: Role-Based Access Control is a security model used to restrict system access based on user roles. Instead of giving permissions directly to each user, permissions are assigned to roles, and users are assigned to these roles. In this system, the main roles are **Student, Instructor, and Admin**. Each role has different permissions. For example, a student can enroll in courses and attempt quizzes, an instructor can create and manage courses, and an admin can manage users and system settings.

When a user tries to access a resource, such as viewing a course, posting in the discussion forum, or generating a roadmap, the system first checks the user's role. Then it verifies whether that role has permission to perform the requested action. If the permission exists, access is granted; otherwise, it is

denied. This process ensures that users cannot perform actions outside their authority.RBAC improves system security by preventing unauthorized access.

- **B-Tree Indexing**: B-Tree indexing is a data structure technique used in databases to improve the speed of data search and retrieval. A B-Tree is a self-balancing tree structure in which data is stored in sorted order and distributed across multiple levels (nodes). Each node can contain multiple keys and child pointers, which reduces the height of the tree and allows faster searching.

In this system, B-Tree indexing is applied to important database fields such as **userId, courseId, and timestamps**. When a query is executed, instead of scanning the entire database table or collection, the database uses the B-Tree index to directly locate the required records. This reduces the time complexity of search operations from linear time (O(n)) to logarithmic time (O(log n)).

B-Tree indexing also improves performance for range queries, such as finding all progress records within a specific date range or retrieving all courses created by a particular instructor. Because the tree remains balanced after insertions and deletions, data access remains efficient even as the database grows.

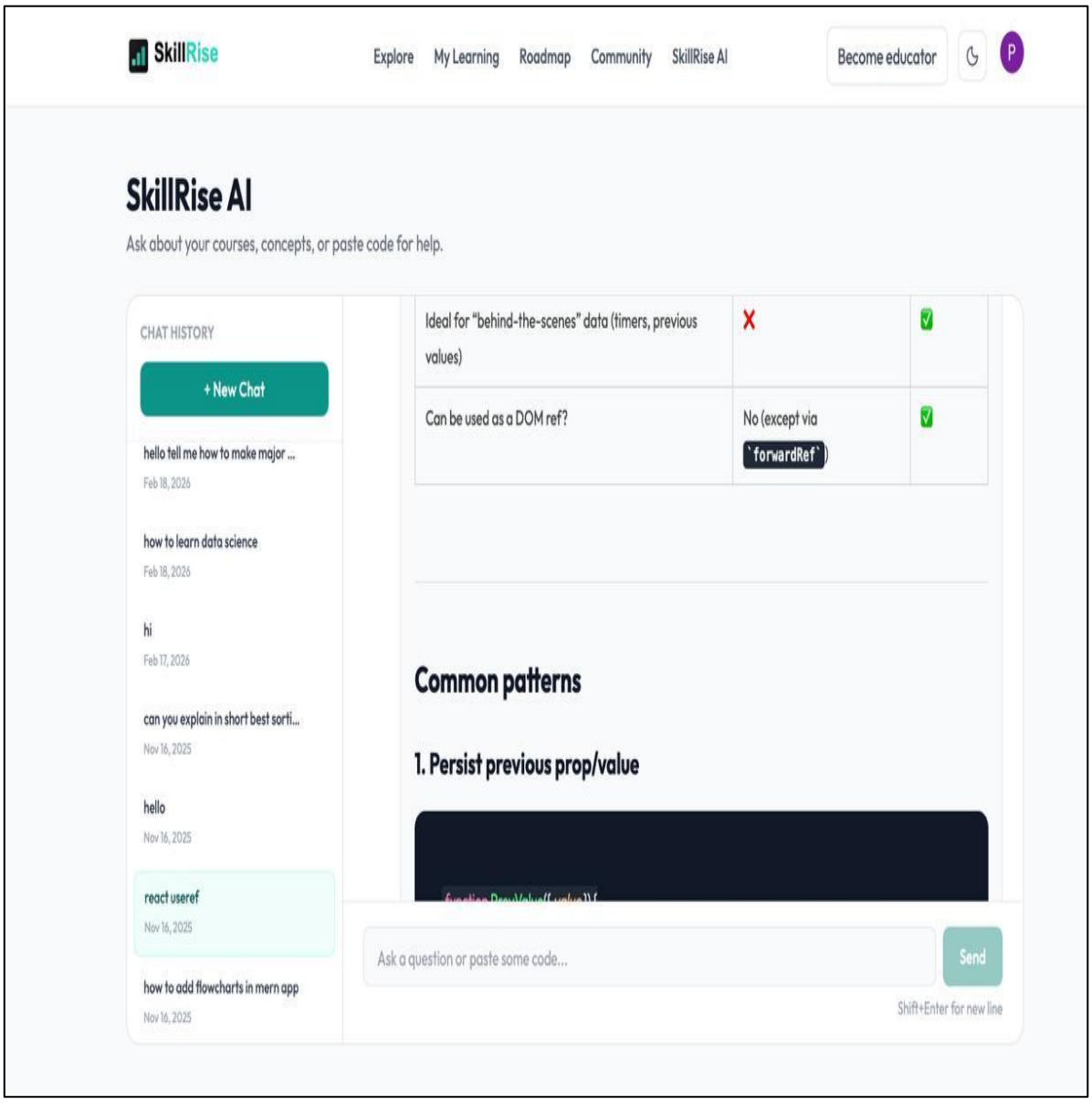
- **Transformer-Based Self-Attention**: Transformer-based self-attention is used in the AI module for understanding user queries and generating chatbot responses. The model processes input text through embeddings and attention mechanisms to capture contextual meaning. This allows accurate and context-aware chatbot interaction and roadmap generation based on learner input.

In this method, the input text (user query) is first converted into numerical representations called embeddings. These embeddings are then transformed into three vectors: Query (Q), Key (K), and Value (V). The attention mechanism calculates how much attention each word should give to other words by computing similarity scores between queries and keys. These scores are normalized and used to weight the values, producing a context-aware representation of the input.

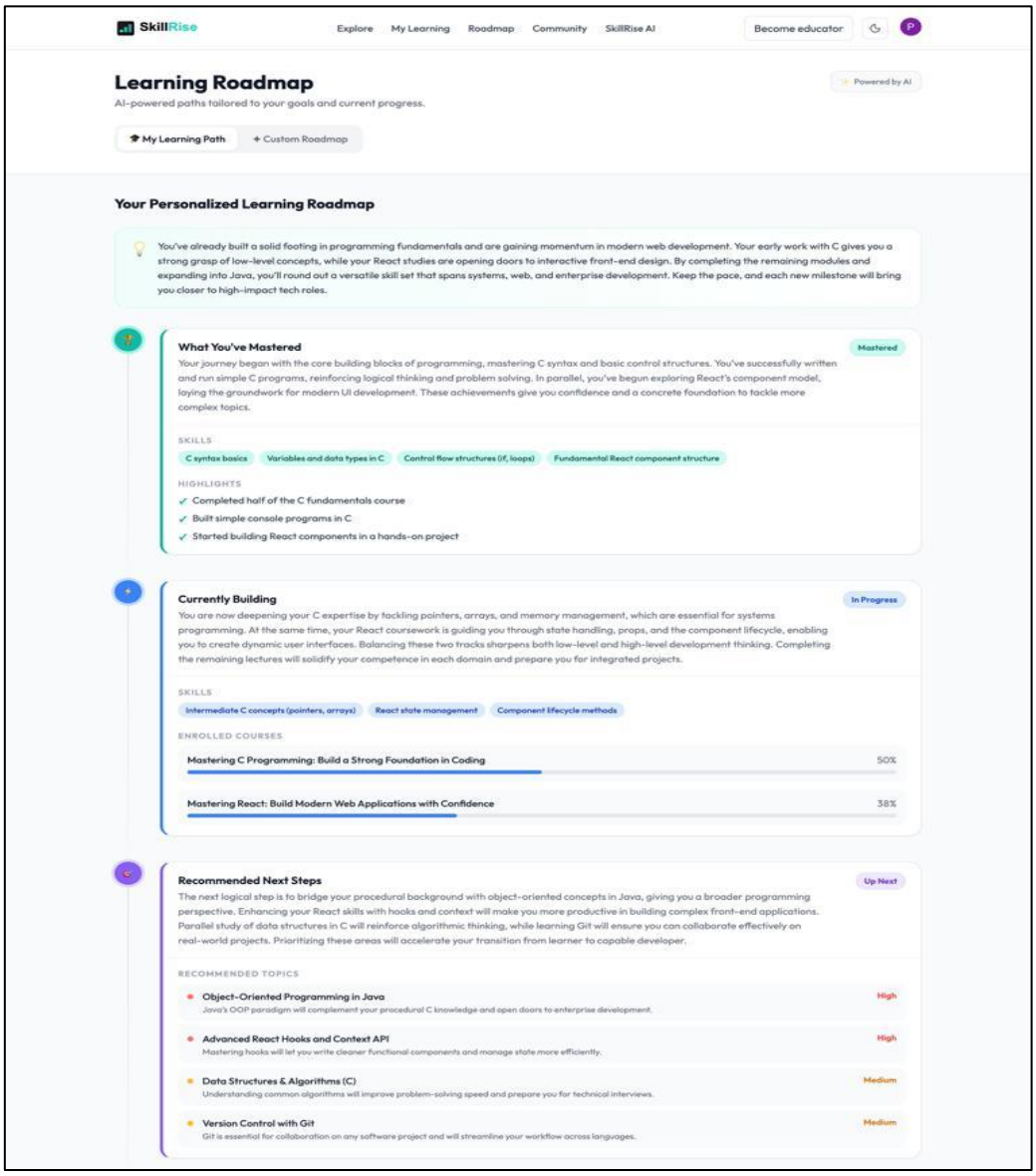
4. RESULT

The system was successfully implemented using the MERN stack and tested with sample users. Students were able to register, log in securely, enroll in courses, participate in quizzes, and access learning materials. The progress tracking module accurately recorded lesson completion and quiz scores. Roadmaps were generated based on learner history and through custom topic selection. The AI chatbot provided instant and relevant responses to user queries. The community discussion forum enabled interaction between students and instructors. Certificates were generated and issued after successful course completion. Performance evaluation showed low response time and stable operation under multiple user requests, indicating improved learner engagement and system efficiency.

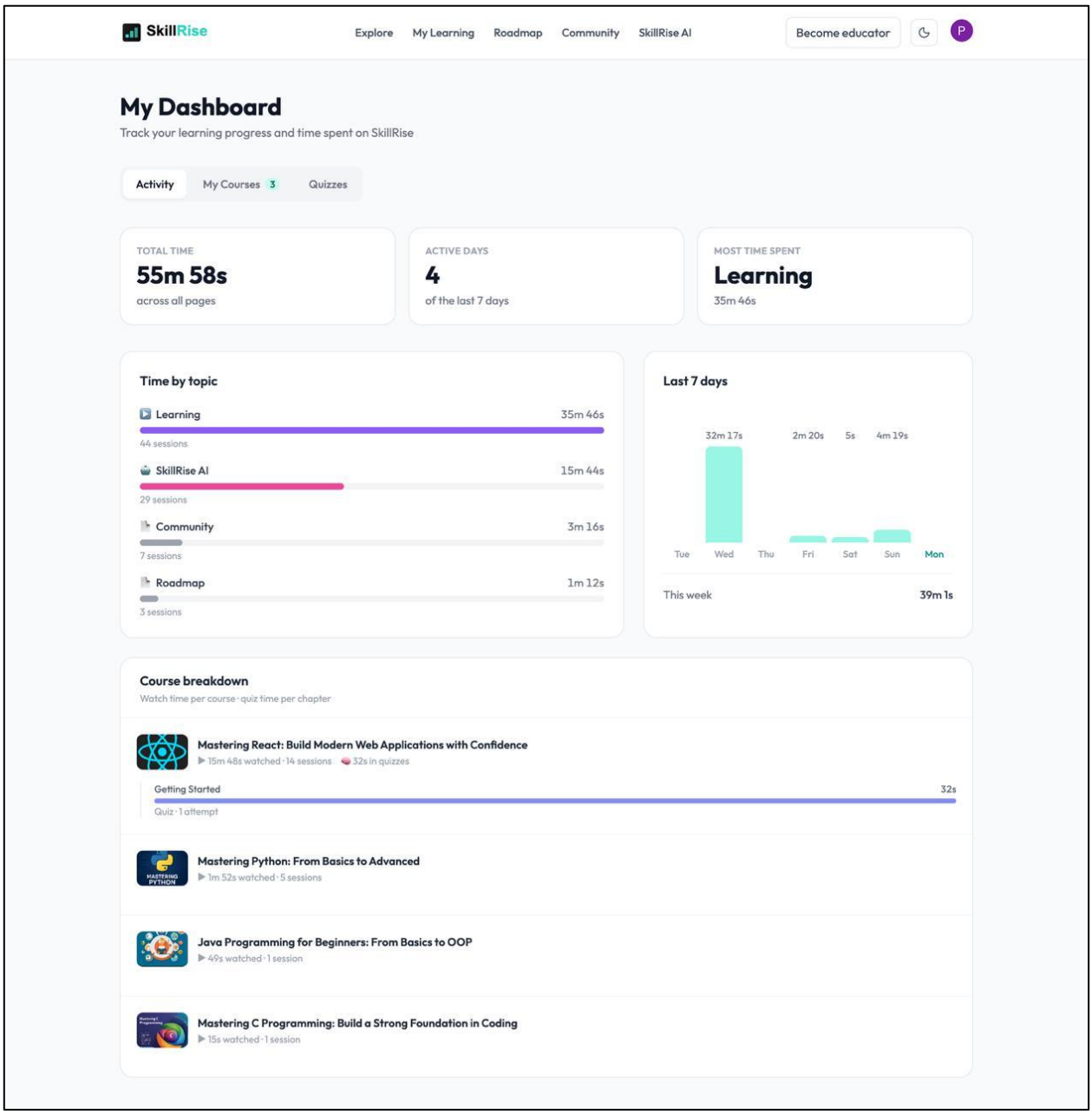
4.1 AI Chat Assistant:
Provides instant responses to student queries based on course content. It helps students understand difficult topics and reduces dependency on instructors for small doubts.



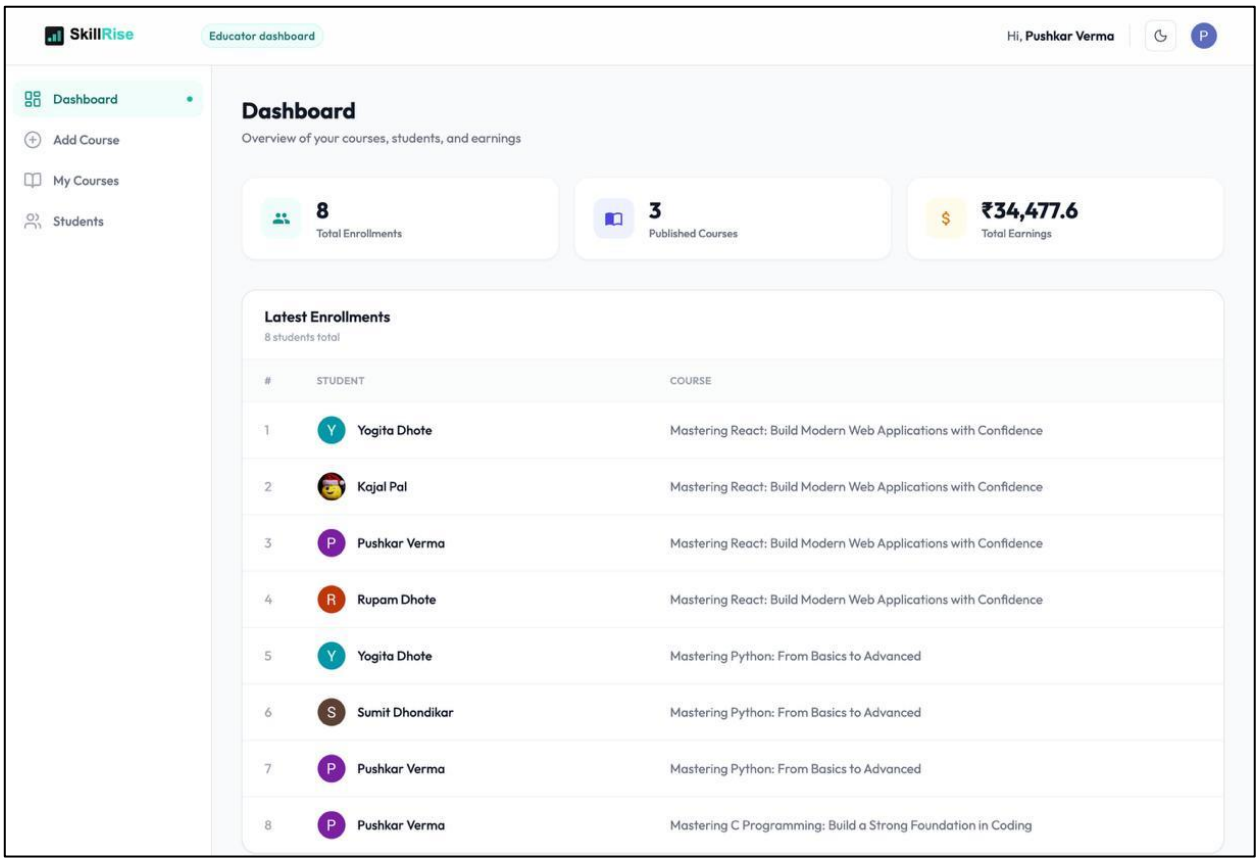
4.2 Roadmap Generation Module:
Generates a structured learning roadmap based on the student's previous learning behavior such as completed topics and quiz performance. It also allows students to create a custom roadmap by selecting any topic or technology like Web Development or Java.



4.3 Progress Tracking System:
Tracks student activities such as lessons completed, quizzes attempted, and time spent on learning. It displays learning progress in the form of daily and weekly analytics.



4.4 Course Management Module:
Allows instructors to create and manage courses, upload learning materials, and assign quizzes. Students can enroll in courses and access learning content through their dashboard.



5. CONCLUSION

The AI-based e-learning platform makes online learning smart and adaptive.
The proposed AI-powered roadmap-based e-learning platform provides structured guidance and intelligent support for digital learning. It integrates roadmap generation, AI chatbot assistance, quizzes, progress tracking, community interaction, and certification into a single system. Guided learning paths replace random content exploration and improve learner organization and engagement. Discussion forums support collaborative learning, while certification motivates course completion. Secure authentication and scalable architecture ensure reliable system performance. Overall, the results show that combining roadmap-based learning with AI support significantly enhances the effectiveness of e-learning platforms.

REFERENCES:

1. Li, X., & Zhao, L. (2024). "*Knowledge Tracing Models for Personalized E-Learning". Elsevier Education Journal*, Vol. 18, Issue 4.
2. Gupta, M. (2024). "*E-Learning Platform Development Using MERN Stack for Scalable Web Apps". International Journal of Creative Research Thoughts (IJCRT)*, Vol. 9.
3. Verma, R., & Bansal, K. (2024). "*Future of Education: Integration of AI in Learning Systems". International Journal for Research in Applied Science and Engineering Technology (IJRASET)*, Vol. 12.
4. Sharma, N., & Gupta, P. (2023). "*AI-Based Adaptive Learning Systems: A Review." International Journal of Innovative Research in Computer Science*, Vol. 11, Issue 2.

5. Smith, J., & Brown, T. (2023). "*Enhancing E-Learning with Artificial Intelligence". Journal of Modern Education*, Vol. 15.
6. Williams, D., & Clark, S. (2023). "*Role of Chatbots in Smart Education Platforms". International Research Journal of Engineering and Technology (IRJET)*, Vol. 10, Issue 7.
7. Khan, S., & Rahman, M. (2023). "*AI-Powered Recommendation Systems in Online Learning". Springer Open Education Research*, Vol. 7, Issue 2.
8. Johnson, L. (2023). "*Tracking Student Progress with Data Analytics in E-Learning". International Journal of Science and Technology*, Vol. 5, Issue 11.
9. Kumar, R., & Singh, A. (2022). "*Artificial Intelligence in Education: Improving Learning Outcomes". International Journal of Engineering Research & Technology (IJERT)*, Vol. 9, Issue 5.
10. Patel, A., & Mehta, R. (2022). "*Machine Learning Techniques in Personalized E-Learning Systems". International Journal of Computer Applications*, Vol. 12, Issue 3.