Personalized Learning Pathway for Engineering Students

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***Abstract*— In the evolving landscape of education, personalized learning is crucial for optimizing student engagement and academic growth. The Personalized Learning Pathway for Engineering Students is a MERN stack-based platform that provides an adaptive and structured learning experience. The system ensures secure authentication, granting students access to a dedicated dashboard where they can attempt quizzes and assignments. Simultaneously, administrators can manage and update assessments through a centralized admin panel. A dynamic progress tracking system continuously evaluates student performance, generating personalized recommendations and learning paths to enhance subject mastery. This real-time, data-driven approach empowers students with targeted resources, helping them improve in weaker areas. Developed using VS Code, the platform offers a scalable, interactive, and responsive learning environment tailored to individual needs, fostering a more effective and engaging academic journey.**

***Keywords*- Assessment-Based Learning, MERN Stack, Progress Tracking.**

I. INTRODUCTION

In modern education, personalized learning has become essential for addressing the diverse learning needs of students. Traditional teaching methods often fail to accommodate individual learning styles, making it challenging for engineering students to grasp complex concepts effectively. The Personalized Learning Pathway for Engineering Students is designed to overcome this limitation by providing a structured and adaptive learning experience. Built using the MERN stack, this platform enables students to engage in self-paced learning, track their progress, and receive personalized recommendations based on their performance. By leveraging data-driven insights, the system enhances student engagement, ensuring they focus on areas that need improvement while strengthening their overall understanding of the subject.

The system comprises two key modules: the Student Dashboard and the Admin Dashboard. Through a secure login system, students can access assessments tailored to their learning progress, receive real-time feedback, and improve their subject knowledge. The Admin Dashboard allows administrators to efficiently create and manage assessments while monitoring student performance. The progress tracking system continuously analyzes student responses, helping them bridge learning gaps and achieve academic excellence. With its scalable and interactive design, developed using VS Code, this platform ensures a seamless and effective learning experience tailored to the evolving needs.

II. LITERATURE REVIEW

1] Alvi, Mohammad Aamash, et al. In this paper, the author created StudyNotion, a cutting-edge educational technology (ed-tech) platform created to transform the way students' study while giving educators a strong platform to share their knowledge with the world. The platform, which is based on the MERN stack and makes use of ReactJS, NodeJS, MongoDB, and ExpressJS, provides a smooth and engaging interface for producing, consuming, and rating instructional content. An extensive description of StudyNotion is provided in this research paper, together with information on its system architecture, front-end and back-end designs, API structure, deployment procedure, testing techniques, and possible future improvements. High-level diagrams that show how StudyNotion's numerous components integrate and interact are used to illustrate the system architecture. With the help of frameworks, libraries,

and tools specially designed for a dynamic learning environment, the front-end architecture places a strong emphasis on user interface design with the goal of improving accessibility and engagement.

2] Uriawan, Wisnu, et al. This study introduces a web-based learning environment that is focused on teaching programming. Leveraging the MERN stack, while also integrating TypeScript for improved code reliability, Next.js for accelerated React.js functionality, Tailwind CSS for responsive design. Backend features include media management with Cloudinary, secure video streaming with VdoCipher, data storage with MongoDB, and caching with Redis. Iterative development will be following agile methodology. In order to create a vibrant and encouraging learning environment the platform includes interactive course pages multimedia content real-time feedback mechanisms and community-building tools. Despite some early difficulties the implementation phase effectively achieved development goals.

3] Wardaya, Utara Setya, et al. In this paper, the author presents This research employing the Agile model, which was systematically planned and organized. The Agile model is an approach that allows for continuous adjustments during development. The aim of this study is to integrate artificial intelligence into an e-learning system to detect and evaluate students' emotions, thereby enabling the development of more effective online learning methods. The design process following the Agile Method involves analysis, modeling with UML (Use Case, Activity Diagram, Sequence Diagram, and Class Diagram), as well as database and code implementation. The backend development focused on database management, server configuration, and API integration, while the frontend was designed for a responsive user interface.

4] Kushwaha, Prince, et al. This research paper explores the development, implementation, and impact of SmartLearnHub, focusing on its adaptive learning paths, personalized quizzes, and intelligent content recommendations. The study delves into the system's architecture, machine learning models employed, and the resulting user engagement and performance metrics. Through a comprehensive evaluation, we highlight the positive impact of SmartLearnHub on the education landscape, emphasizing the significance of AI in tailoring educational experiences. The paper concludes with insights into challenges faced during implementation, future directions for enhancement, and the potential influence of SmartLearnHub on the future of AI-driven education.

5] Akter, Khusbu, et al. This analysis provides a foundation for ongoing exploration and development, emphasizing Edu Sync's potential to revolutionize administrative processes and enrich student learning experiences in the digital age. Edu Sync emerges as a pioneering solution for educational institutions striving to modernize administrative workflows and enhance student engagement in the digital era. Positioned as an intuitive platform tailored for schools, colleges, and universities, Edu Sync offers a comprehensive suite of features aimed at simplifying academic operations and fostering seamless communication between educators and students. The primary objective of Edu Sync is to optimize the management of academic schedules and facilitate online learning experiences through a user-friendly interface. Beyond its current capabilities, this analysis explores its potential to evolve into a holistic learning management system (LMS), catering to the diverse needs of modern educational environments. Edu Sync's intuitive design and versatile feature set make it an ideal tool for promoting student participation in remote learning, a pivotal aspect of contemporary education. In addition to managing academic schedules, Edu Sync empowers students by providing access to their routines and online class links directly from their personalized panels.

6] Badru, Lawal Olarotimi, This study examines the existing EMIS in the Pacific Island Countries PICs and proffers solutions. A SWOT analysis on the selected PICs EMIS through the published technical reports and policy documents from government and donors' between the years 2000 and 2021, revealed that EMIS in PICs have not progressed beyond the stages of collecting demographic data and generating basic indicators. Fiji EMIS, which has the prospect of leading other PICs EMIS could only generate a few indicators manually, and the findings indicate that these indicators are not being considered in decision making. To solve these defects, we proposed data-driven microservices architecture developed with MERN (MongoDB, ExpressJS, ReactJS, and NodeJS) stack on 13 NoSQL collections, tested with pseudonymised data from Fiji Ministry of Education

(consisting of 98.6% Learners, 100.2% Schools and 99.5% Teachers in post).

7] Ramyadevi, R., et al. This system will forecast and present the user's learning path. This solution fully integrates with many databases and provides cross-browser usage. This system's key features included Content Management and Content Protection, Evaluation management, Access Control, etc., are mainly focused on integrated platforms needed for online learning and management. For Frontend we are going to use ReactJS and for Backend is Nodejs. This System will be built on the MERN stack. Proposed method identifies frames with 80% accuracy.

8] Arora, Karishma, et al. The work presented in this paper is known as 'Developer's Hub', which encapsulates the idea of freelancing with MERN stack in an optimized way over the web. MERN stack, as the name suggests is stack of four different technologies which are MongoDB, Express.js, React.js, Node.js. This paper reflects the significance of freelancing and the technologies concerned in MERN stack. It includes the implementation of MERN for optimizing freelancing over the web. The paper also includes challenges faced by freshers or experienced people in the freelancing market with the growth in demand of the freelancing world.

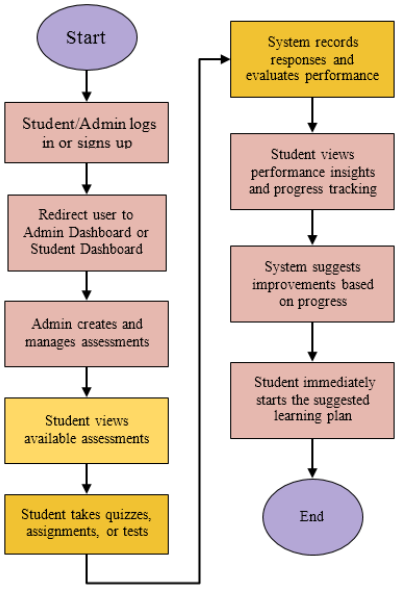
9] Kushwaha, Prince, presented This research paper explores the development, implementation, and impact of SmartLearnHub, focusing on its adaptive learning paths, personalized quizzes, and intelligent content recommendations. The study delves into the system's architecture, machine learning models employed, and the resulting user engagement and performance metrics. Through a comprehensive evaluation, we highlight the positive impact of SmartLearnHub on the education landscape, emphasizing the significance of AI in tailoring educational experiences. The paper concludes with insights into challenges faced during implementation, future directions for enhancement, and the potential influence of SmartLearnHub on the future of AI-driven education.

10] Heim, Sophie, proposed In our paper, we design, implement, and evaluate a new learning management system (LMS) specifically for lecturers following a design science research approach to perform a proof of concept and to assess the acceptance within the community. We gather the requirements for this LMS by performing a literature review, and afterward, we build a web application as an artefact prototype and evaluate it in an exploratory focus group. The developed LMS covers basic functionalities, user control, and collaboration tools to support communication between lecturers. Other features include the upload and management of courses and their contents.

III. METHODOLOGY

The Personalized Learning Pathway for Engineering Students is a MERN stack-based system designed to provide a structured and adaptive learning experience. The system begins with a secure login and signup page, allowing students and administrators to access their respective dashboards. The admin dashboard enables administrators to create and manage assessments, ensuring a continuous evaluation process. Once assessments are added, students can access them through their personalized student dashboard, where they can attempt quizzes, assignments, or other evaluation tasks. The system then tracks the student's performance and progress, providing insights and feedback through a progress tracking module. This helps students identify their strengths and weaknesses, enabling them to improve in specific areas. The entire platform is developed using the MERN stack, ensuring a responsive and scalable learning environment, with VS Code as the development platform.

FLOW CHART



WORKING

The Personalized Learning Pathway for Engineering Students operates through a seamless interaction between students and the system. Once logged in, students can navigate their dashboard to access assigned assessments. As they attempt quizzes or assignments, their responses are automatically recorded and evaluated in real time. The system continuously analyzes their performance, tracking their progress and identifying areas that need improvement. Based on this analysis, personalized recommendations are generated, guiding students toward targeted learning resources or additional assessments. This adaptive approach ensures that students receive real-time feedback and can immediately begin working on their suggested learning path. Meanwhile, administrators can monitor student engagement and modify assessments as needed to enhance the learning experience.

IV. SYSTEM REQUIREMENT

SOFTWARE REQUIREMENT

1) MERN Stack
2) VS Code

V. IMPLEMENTATION & RESULT

IMPLEMENTATION

Step 1: User Authentication and Login

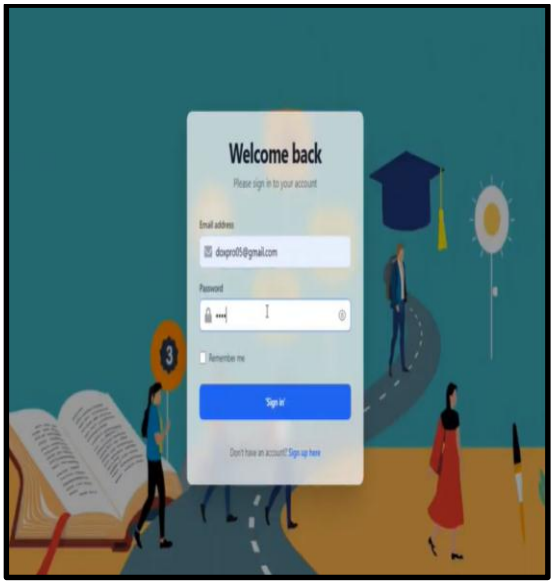


Fig. Shows Login Interface for Admin Access

Step 2 Admin Dashboard - Assessment Management

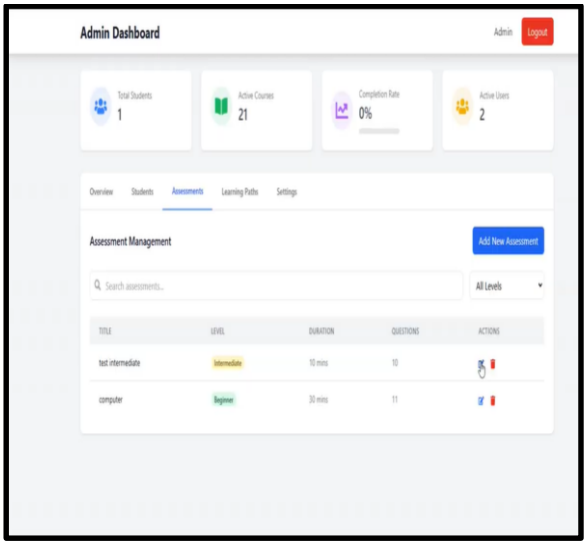


Fig. Shows Admin Dashboard Showing Assessment Management Interface

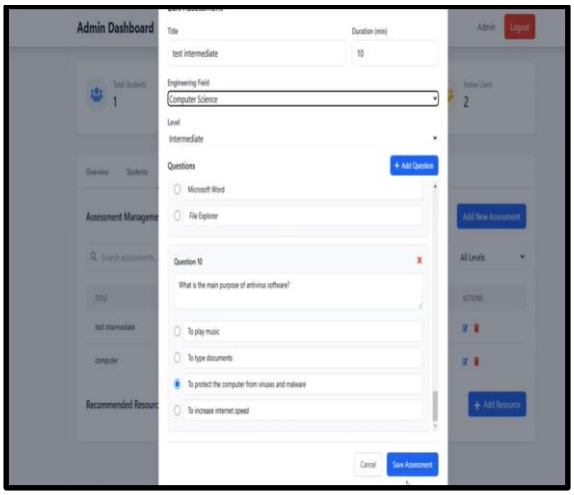


Fig. Shows Admin Dashboard - Editing an Assessment with Question Details

The administrator can edit the "test intermediate" assessment, which includes multiple-choice questions. The "Add Question" button enables the addition of new questions to the assessment, while the "Recommended Resources" section allows administrators to link relevant learning materials. The form provides clear input fields for question text and answer options, with radio buttons for selecting the correct answer. The "Cancel" and "Save Assessment" buttons at the bottom allow administrators to either discard or save their changes. This interface ensures that administrators can create and maintain a comprehensive and up-to-date assessment library, tailored to the specific needs of engineering students.

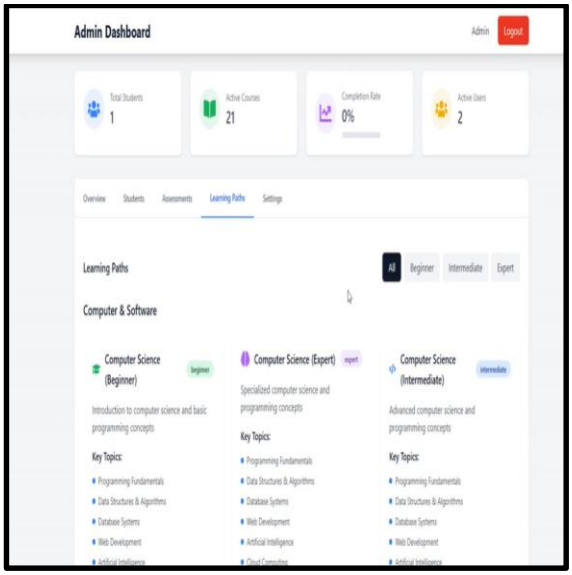


Fig. Shows Admin Dashboard Showing Learning Path Management Interface

This figure showcases the "Learning Paths" section of the admin dashboard. The interface allows administrators to define learning paths based on different categories, such as "Computer & Software," and organize them by proficiency levels: Beginner, Intermediate, and Expert. Each learning path includes a description, key topics, and a visual representation of its progression. Administrators can filter learning paths by level using the tabs at the top right, providing a clear overview of the available options. This feature enables the creation of personalized learning journeys for students, guiding them through a structured curriculum tailored to their skill level and interests.

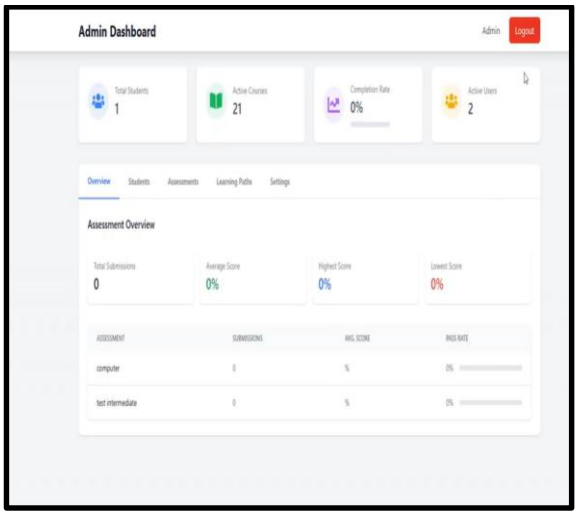


Fig. Shows Admin Dashboard Displaying Assessment Overview and Performance Metrics

This figure illustrates the "Assessment Overview" section of the admin dashboard, providing administrators with a snapshot of student performance across various assessments. The overview includes key metrics such as total submissions, average score, highest score, and lowest score. In this example, the metrics show 0% for all categories, indicating that no assessments have been submitted yet. The dashboard also lists individual assessments, including "computer" and "test intermediate," along with their submission count, average score, and pass rate. This interface allows administrators to track student progress, identify areas where students may be struggling, and make data-driven decisions to improve the learning experience.

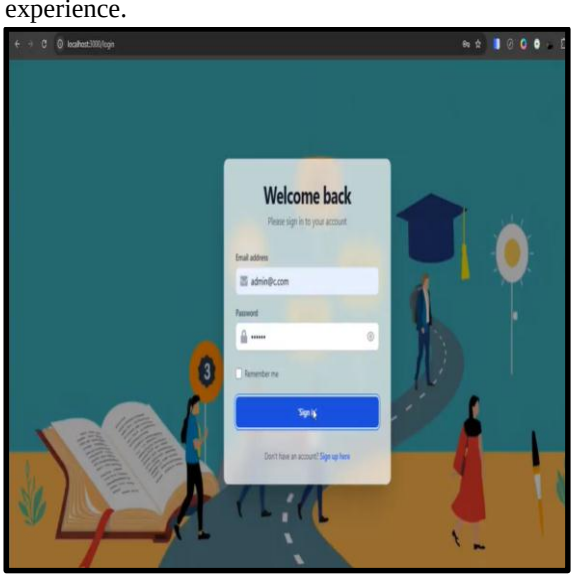


Fig. Shows Login Interface for Student Access

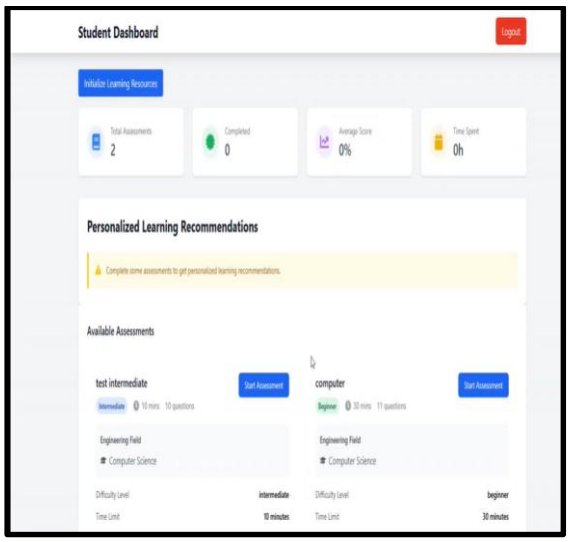


Fig. Shows Student Dashboard Displaying Available Assessments and Performance Summary

The dashboard displays key performance metrics, including total assessments, completed assessments, average score, and time spent. In this example, the

student has two assessments available ("test intermediate" and "computer"), but has not completed any yet, as indicated by the 0% average score and 0 hours spent. The "Personalized Learning Recommendations" section prompts students to complete assessments to receive tailored recommendations. The "Available Assessments" section lists the assessments with details such as title, engineering field, difficulty level, and time limit, with a "Start Assessment" button for each. The "Initialize Learning Resources" button suggests the availability of additional resources.

Step 3: Student Dashboard - Accessing and Starting Assessments

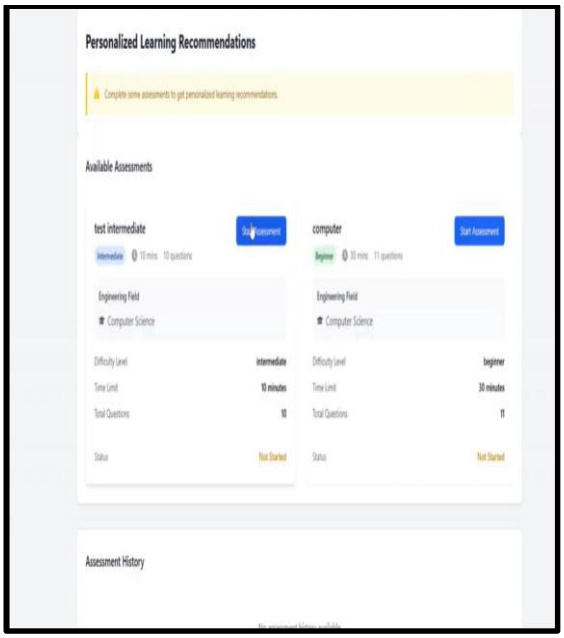


Fig. Shows Student Dashboard Indicating Student Intent to Begin an Assessment

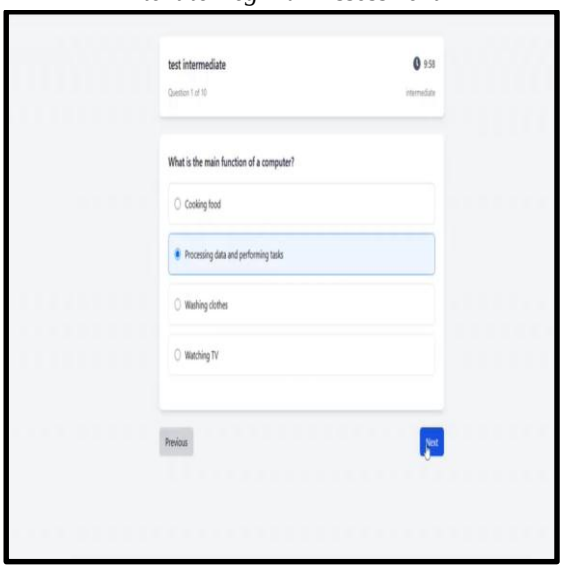


Fig. Shows Student Actively Solving Assessment Questions

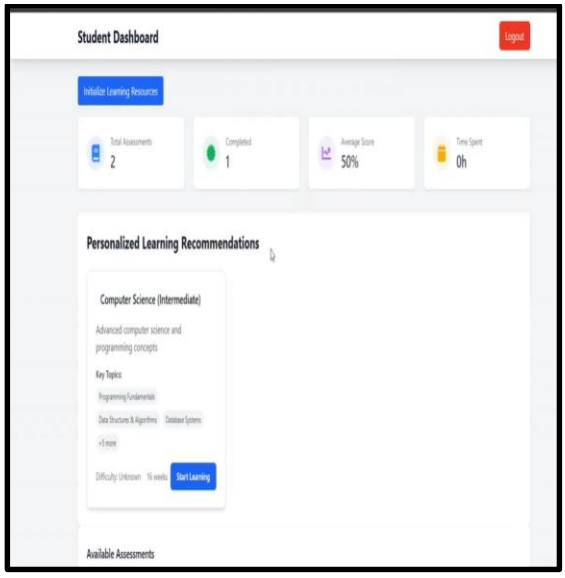


Fig. Shows Student Dashboard Showing Updated Performance Metrics and Personalized Recommendations After Assessment Completion

This figure illustrates the student dashboard after the student has completed one assessment. The "Total Assessments" remains at 2, but the "Completed" count has increased to 1, indicating that the student has successfully finished an assessment. The "Average Score" is now 50%, reflecting the student's performance on the completed assessment. The "Time Spent" remains at 0 hours. The "Personalized Learning Recommendations" section now displays a specific recommendation, "Computer Science (Intermediate)," with key topics and a "Start Learning" button, indicating that the platform is now generating personalized learning paths based on the student's assessment performance.

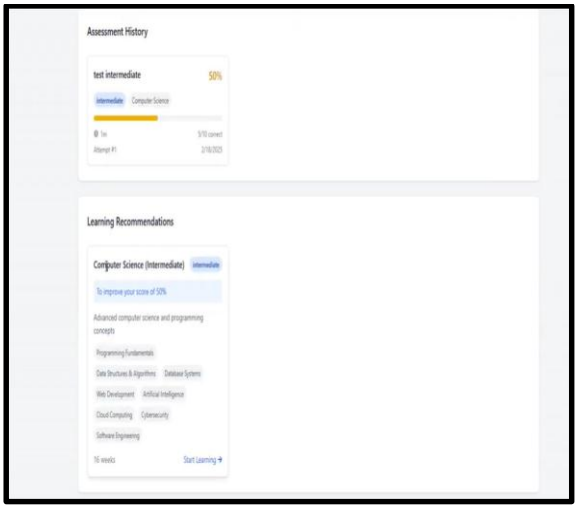


Fig. Shows Student Dashboard Showing Detailed Assessment History and Personalized Learning Recommendations After Assessment Completion

The "Assessment History" section displays the completed "test intermediate" assessment, showing a score of 50%. It also includes details such as the engineering field ("Computer Science"), a progress bar indicating 3 out of 10 questions answered correctly, and the date of the attempt ("2/18/2023"). The "Learning Recommendations" section provides a personalized learning path, "Computer Science (Intermediate)," tailored to the student's performance. It includes a message encouraging the student to improve their score, a list of key topics (e.g., "Programming Fundamentals," "Data Structures & Algorithms"), and the estimated duration of the learning path ("16 weeks").

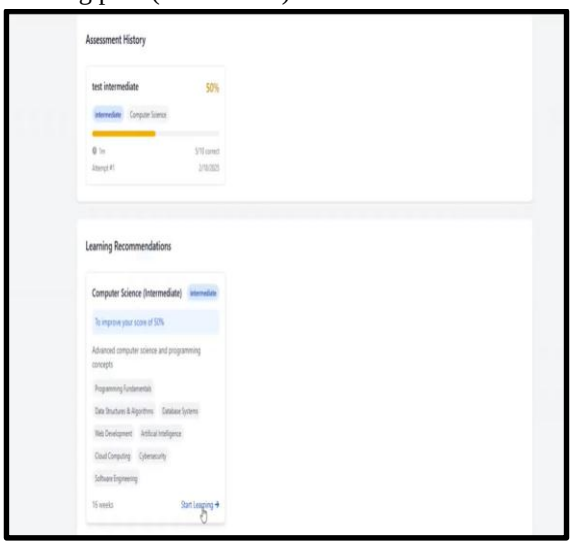


Fig. Shows Student Dashboard - Initiating a Personalized Learning Path

The "Start Learning" button allows the student to immediately begin the recommended learning path. This detailed view highlights the platform's ability to track student progress and provide actionable recommendations based on assessment results.

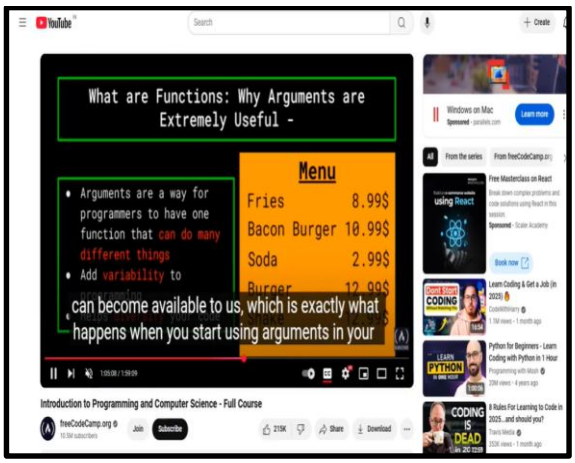


Fig. Shows a YouTube Video on Programming Concepts Integrated into the Learning Path

This figure demonstrates the integration of external learning resources, specifically a YouTube video, into the personalized learning pathway. The fig. shows a section of the "Introduction to Programming and Computer Science - Full Course" from freeCodeCamp.org, which is being used to teach students about functions and arguments. This integration allows students to access a variety of learning materials, including video tutorials, to supplement their understanding of key concepts. The platform's ability to incorporate external resources, such as YouTube videos, enhances the learning experience by providing students with diverse perspectives and teaching styles. This ensures that students have access to comprehensive and engaging learning materials, supporting their progress in the personalized learning pathway.

VI. CONCLUSION

The Personalized Learning Pathway for Engineering Students redefines education by leveraging technology to create a more adaptive and student-centric learning experience. Through assessment-based progress tracking and personalized recommendations, the system empowers students to focus on areas that need improvement while enhancing their overall academic performance. Its self-paced learning model ensures flexibility, allowing students to learn at their own speed, while administrators benefit from streamlined assessment management and real-time performance insights. Built on a MERN stack architecture, the platform is scalable and responsive, with the potential for future enhancements such as AI-driven recommendations, peer learning, and gamified assessments to boost engagement. By continuously refining learning pathways through real-time data analysis, the system fosters continuous improvement in education. With its intuitive interface and data-driven approach, this platform has the potential to revolutionize engineering education, bridging knowledge gaps effectively and improving learning outcomes.

VII. REFERENCE

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