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CodeMaster : AI - Powered Programming Skills Assessment Platform

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Abstract: *The growing demand for programming literacy has highlighted the need for intelligent assessment systems capable of accurately evaluating coding skills across multiple languages and varying difficulty levels. Traditional assessment methods often rely on static question banks and lack personalized feedback, which limits learners' ability to identify and address their knowledge gaps effectively. To overcome these limitations, this project, CodeMaster: AI-Powered Programming Skills Assessment Platform, introduces a modern solution developed using Angular 21, ASP.NET Core (C#), and SQL Server. The platform supports multiple programming languages, including Python, Java, C, and C++, and offers assessments across three levels of difficulty. It leverages artificial intelligence to dynamically generate diverse question types such as multiple-choice and true/false questions, ensuring a more adaptive and engaging evaluation process. Additionally, the system incorporates intelligent performance analytics that monitor user progress, identify weak areas, and provide detailed explanations for better understanding. Secure user authentication is ensured through JWT implementation. By delivering personalized feedback and comprehensive performance tracking, CodeMaster promotes systematic skill development, supports continuous learning, and contributes to building a technically proficient workforce with validated programming expertise*

Keywords: *CodeMaster*

I. INTRODUCTION

In today's rapidly evolving technological landscape, programming skills have become essential across a wide range of industries, making effective skill assessment and continuous learning increasingly important for educational institutions and professional organizations alike. Students, job seekers, and working professionals often need to validate their programming expertise in languages such as Python, Java, C, and C++. However, many existing assessment tools rely on static question banks with limited personalization, which restricts their ability to accurately evaluate skill levels and identify specific knowledge gaps.Consequently, learners often struggle to recognize their areas of weakness and improve in a systematic manner, while educators and recruiters lack reliable mechanisms to comprehensively assess programming proficiency. Traditional systems typically provide only basic outcomes, such as pass or fail results, without offering meaningful feedback or actionable insights. This limitation highlights the growing need for intelligent and adaptive assessment platforms that not only evaluate programming knowledge but also analyze performance patterns to deliver personalized learning recommendations.A detailed understanding of a learner's strengths and weaknesses at a granular level can significantly enhance skill development by enabling targeted learning interventions. Furthermore, the integration of AI-driven question generation facilitates the creation of fresh, diverse, and contextually relevant assessments, reducing the likelihood of memorization and promoting a deeper understanding of programming concepts.To address these challenges, this project proposes CodeMaster: AI-Powered Programming Skills Assessment

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Platform, an intelligent web-based system designed to evaluate programming knowledge through AI-generated questions and advanced analytics. The platform generates customized assessments across multiple programming languages and difficulty levels, identifies weak areas using intelligent algorithms, and provides detailed explanations for incorrect responses. By supporting continuous learning, targeted improvement, and data-driven skill development, CodeMaster contributes to enhancing programming proficiency in the modern digital era.

II. RELATED WORK

The evaluation of programming skills has evolved significantly with the growth of online learning platforms. Traditional assessment systems primarily relied on static question banks and fixed test formats, which limited their ability to adapt to individual learner needs. These systems typically provided only basic scoring without detailed feedback, making it difficult for learners to identify and improve their weak areas.Modern platforms such as HackerRank and CodeChef introduced interactive coding environments and multi-language support, enabling users to practice programming through real-time problem-solving. However, these platforms are largely competition-oriented and offer limited personalized feedback or learning guidance.Recent research has focused on adaptive assessment systems that adjust question difficulty based on user performance. While these approaches improve evaluation accuracy, they often depend on predefined question sets and lack scalability. The emergence of artificial intelligence has further enhanced assessment methods by enabling automatic question generation and performance analytics. These techniques help create diverse assessments and provide better insights into learner progress.Despite these advancements, there remains a need for an integrated system that combines AI-based question generation, multi-language support, and detailed performance analysis. The proposed CodeMaster platform addresses this gap by offering personalized assessments and feedback for continuous skill improvement.

III. LITERATURE REVIEW

1. Weak Topic Identification and Personalized Learning
Authors: N. Patel, M. Desai, & K. Shah (2023)
Explanation:
This study focuses on identifying knowledge gaps in programming education using machine learning and statistical techniques. The system analyzes learner performance across multiple assessments, applying clustering and classification methods to detect topic-wise weaknesses. Factors such as response accuracy, time taken, and error patterns are used to determine conceptual understanding. The platform then provides targeted recommendations to improve learning outcomes. Results indicate significant improvements in learner retention and reduced time required to master programming concepts.
Additional Issues: Requires real-time adaptability and integration with dynamic question generation systems.

2. Multi-Language Programming Assessment Platforms
Authors:M. Anderson & D. Williams (2023)
Explanation:
This paper presents a unified framework for assessing programming skills across multiple languages including Python, Java, C, and C++. It introduces a language-agnostic approach to maintain consistency in difficulty levels while addressing language-specific features. Adaptive algorithms are used to adjust question complexity based on learner performance. The study demonstrates improved accuracy in evaluating programming proficiency across different paradigms.
Additional Issues:Maintaining consistency across languages with different paradigms remains challenging.

3. Performance Analytics and Dashboard Visualization
Authors: R. Garcia, T. Nguyen, & L. Peterson (2023)

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Explanation:
This paper highlights the importance of learning analytics in programming education through interactive dashboards. The system tracks performance metrics such as accuracy, topic proficiency, and progress over time, presenting them using visual tools like graphs and heatmaps. These insights help learners understand their progress and enable instructors to make data-driven decisions.
Additional Issues: Needs improved personalization and real-time analytics for better user experience.

IV. PROBLEMSTATEMENT

Traditional programming assessment systems are limited in their ability to support effective learning, as they primarily provide final scores without identifying specific weak topics or knowledge gaps. This makes it difficult for learners to understand their deficiencies until they face failure in exams or real-world tasks. Additionally, the use of static question banks promotes memorization rather than true conceptual understanding. Most existing systems lack mechanisms to track topic-wise proficiency or monitor learning progress systematically. Manual performance evaluation further adds complexity, as it is time-consuming and not scalable for large groups of learners. The absence of personalized feedback significantly reduces learning efficiency, resulting in slower skill development and limited improvement outcomes.

V. PROPOSED SYSTEM OVERVIEW

The proposed system, CodeMaster: AI-Powered Programming Skills Assessment Platform, is designed using a layered architecture to ensure efficiency, scalability, and intelligent evaluation. The system begins with the user layer, where learners interact through a responsive frontend built using Angular, HTML, CSS, and TypeScript. Secure authentication is maintained through JWT-based login, password hashing, and session management. The backend, developed using ASP.NET Core, handles business logic and RESTful API communication. An integrated AI processing layer performs dynamic question generation, performance analysis, weak topic identification, and adaptive proficiency calculation. All user data, quiz details, and results are stored in a structured SQL Server database. Finally, the output layer presents meaningful insights such as performance analytics, weak topic identification, and progress reports, enabling learners to track improvement and enhance their programming skills effectively.

VI. SYSTEM ARCHITECTURE

A. Modules

1. User Authentication Module

Description: Handles user registration and login using secure JWT token-based authentication. It implements password hashing and manages user sessions effectively. The module also provides role-based access control to ensure data privacy and secure access to the platform.

2. Quiz Configuration Module

Description: Allows users to customize quiz parameters, including programming language selection (Python, Java, C, C++), difficulty levels (Easy, Medium, Hard), and the number of questions (5, 10, 20). It validates user inputs and forwards the configuration to the backend for quiz generation.

3. AI Question Generation Module

Description: Generates diverse programming questions using the Google Gemini API or a pre-built question bank. It creates a mix of Multiple Choice Questions (MCQs) and True/False questions based on the selected language and difficulty level. The module ensures uniqueness in each quiz attempt to prevent memorization.

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4. Answer Evaluation Module

Description: Automatically evaluates user responses by comparing them with correct answers stored in the database. It calculates the total score, marks each response as correct or incorrect, and records the completion time, providing instant results without manual intervention.

5. Weak Topic Detection Module

Description: Analyzes incorrect answers to identify specific knowledge gaps and weak topics. It calculates topic-wise proficiency scores based on user performance and generates personalized recommendations for targeted improvement.

6. Performance Analytics Module

Description: Tracks and analyzes user performance over time using historical test data. It computes key statistics such as total tests taken, average scores, highest and lowest scores, and progress trends, presenting a comprehensive performance overview through visual charts and graphs.

7. Results Module

Description: Displays detailed explanations for incorrect responses to reinforce learning. It highlights weak areas and provides actionable suggestions to guide users toward improvement.

B. Backend Architecture

The system utilizes a robust backend architecture built on ASP.NET Core and SQL Server to manage authentication, data processing, and communication between system components. The backend ensures secure, scalable, and efficient handling of all application functionalities through RESTful APIs and integrated services.

• Authentication and Security: Implements JWT-based authentication to ensure secure user login and identity verification. Passwords are encrypted using hashing techniques, and session management is handled to maintain secure access control across the platform.

• Database Management (SQL Server): Stores structured data including user profiles, quiz configurations, questions, answers, and test results. The database is designed to support efficient data retrieval and maintain consistency for performance tracking and analytics.

• Backend API (ASP.NET Core): Handles business logic, processes user requests, and manages communication between the frontend and the database. It also integrates with the AI processing layer for dynamic question generation and performance analysis.

• AI Integration Layer: Connects with AI services (such as Gemini API or internal logic) to generate questions, analyze user performance, and identify weak topics, ensuring adaptive and intelligent system behavior.

VII. IMPLEMENTATION DEAILS

The implementation of the proposed CodeMaster: AI-Powered Programming Skills Assessment Platform consists of four main steps: User Authentication and Input, Quiz Configuration and Generation, Answer Evaluation and Weak Topic Detection, and Performance Analytics and Result Visualization.

User Authentication and Input

Users securely access the platform through a login and registration system. New users create accounts by providing necessary details, while existing users authenticate using JWT-based secure login. Passwords are hashed to ensure data protection, and sessions are managed efficiently. All user data is validated and securely stored in the SQL Server database, maintaining data integrity and privacy.

Quiz Configuration and Generation

After successful login, users configure quizzes by selecting the programming language (Python, Java, C, C++), difficulty level (Easy, Medium, Hard), andnumber ofquestions. The system validates these inputs and forwards them to

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the backend API. The AI processing layer generates a set of unique questions using AI-based logic or a predefined question bank, ensuring a mix of MCQs and True/False questions. Each quiz is dynamically generated to avoid repetition and encourage conceptual understanding.

Answer Evaluation and Weak Topic Detection

Once the user submits the quiz, the system automatically evaluates the responses by comparing them with correct answers stored in the database. It calculates the total score, identifies correct and incorrect responses, and records completion time. The system further analyzes incorrect answers to detect weak topics and knowledge gaps. Topic-wise proficiency is calculated using performance patterns, enabling identification of specific areas that require improvement.

Performance Analytics and Result Visualization

The platform generates detailed performance analytics based on user activity and historical data. It provides insights such as average scores, progress trends, and topic-wise performance through interactive dashboards. The results module displays explanations for incorrect answers and highlights weak areas with actionable recommendations. Users can track their progress over time, enabling continuous learning and systematic skill improvement.

SYSTEM ARCHITECTURE

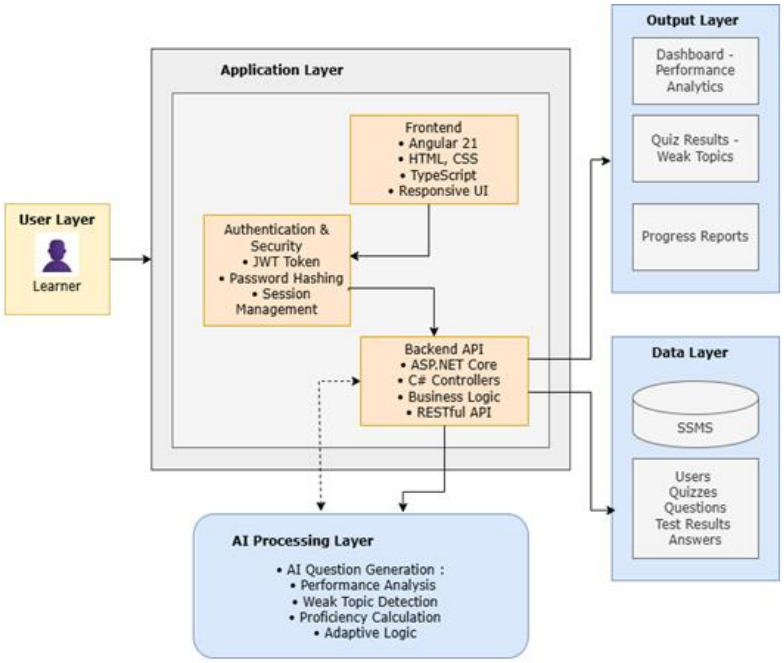

Figure1: System architecture

VIII. PROPOSED SYSTEM

System Architecture:

The system architecture is shown in Figure 1. The proposed system follows a structured and intelligent workflow to assess programming skills effectively.

Step 1:User Registration

Learners register on the platform by providing basic details. The system stores user information securely in the database for future access and tracking.

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Step 2: Login & Authentication
Users log in using secure JWT-based authentication. The system verifies credentials, manages sessions, and ensures authorized access to platform features.

Step 3: Quiz Configuration
Users select quiz parameters such as programming language (Python, Java, C, C++), difficulty level (Easy, Medium, Hard), and number of questions. The system validates inputs and prepares the quiz request.

Step 4: AI-Based Question Generation
The system generates dynamic questions using AI or a predefined question bank. A mix of MCQs and True/False questions is created based on selected parameters, ensuring uniqueness and reducing memorization.

Step 5: Answer Submission and Evaluation
Users attempt the quiz and submit their responses. The system automatically evaluates answers, calculates scores, and records completion time without manual intervention.

Step 6: Weak Topic Detection and Analysis
The system analyzes incorrect responses to identify weak topics and knowledge gaps. It calculates topic-wise proficiency and generates personalized recommendations for improvement.

Step 7: Dashboard and Results
Users receive detailed performance analytics, including scores, progress trends, and weak areas. The system displays explanations for incorrect answers and provides insights through interactive dashboards for continuous learning.

IX. ANALYSIS OF PROPOSED SYSTEM

1. Enhanced Efficiency and Real-Time Insights:
The proposed CodeMaster platform significantly improves the efficiency of programming skill assessment by automating quiz generation, evaluation, and analysis. By integrating modern web technologies with a centralized database and AI capabilities, the system provides real-time results, performance dashboards, and progress insights, reducing manual effort and delays in evaluation.

2. Intelligent Analysis and Personalized Feedback:
The system analyzes user responses to identify weak topics and knowledge gaps using intelligent algorithms. It evaluates performance patterns such as accuracy and response behavior to provide personalized recommendations. This enables learners to focus on specific areas for improvement, enhancing overall learning outcomes and conceptual understanding.

3. Secure Role-Based Access:
The platform ensures secure access through JWT-based authentication and role-based control mechanisms. Users can safely access their data, while administrative controls maintain system integrity, data privacy, and proper management of platform functionalities.

4. Improved Learning and Transparency:
Compared to traditional assessment systems, CodeMaster provides detailed insights through analytics dashboards, including scores, topic-wise performance, and progress trends. This transparency helps learners track their

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improvement over time and supports data-driven learning, resulting in a more structured and effective skill development process.

• MODULES

The proposed Code Master: AI-Powered Programming Skills Assessment Platform is divided into four main modules: User Module, Quiz Module, Analysis Module, and Notification & Results Module. Each module is designed to handle specific functionalities and ensure smooth system operation.

1. User Module

This module manages user registration, login, and authentication. It ensures secure access using JWT-based authentication and maintains user profiles. Users can access the platform, view their quiz history, and track their overall progress over time.

2. Quiz Module

The Quiz Module allows users to configure and attempt programming assessments. Users can select the programming language (Python, Java, C, C++), difficulty level, and number of questions. The system generates dynamic questions using AI or a question bank, ensuring a unique and engaging quiz experience for each attempt.

3. Analysis Module

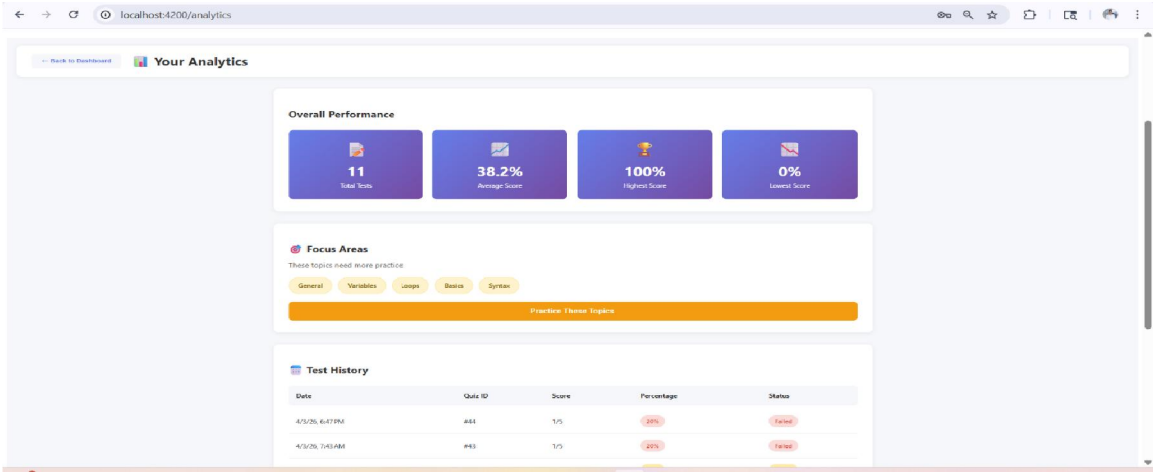
This module analyzes user performance by evaluating quiz results and identifying weak topics. It calculates topic-wise proficiency, tracks progress trends, and provides personalized recommendations for improvement. The module helps users understand their strengths and focus on areas that require further practice.

4. Notification & Results Module

This module displays quiz results along with detailed explanations for incorrect answers. It also provides performance analytics through dashboards and sends updates regarding progress and improvements. This ensures continuous learning and keeps users informed about their performance

X. RESULT

USER ANALYTICS



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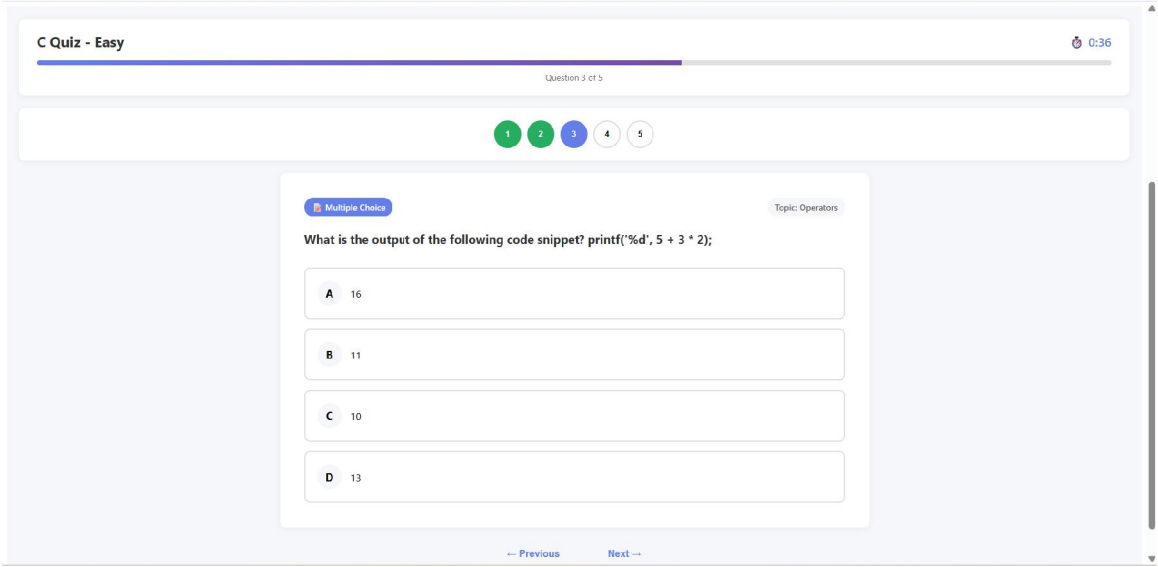
QUIZ GENERATION



XI. CONCLUSION

The CodeMaster: AI-Powered Programming Skills Assessment Platform provides an intelligent and efficient solution for evaluating and improving programming skills. By integrating artificial intelligence with modern web technologies, the system enables dynamic question generation, automated evaluation, and detailed performance analysis. It overcomes the limitations of traditional assessment methods by identifying weak topics and providing personalized feedback for continuous learning.Developed using Angular, ASP.NET Core (C#), and SQL Server, the platform ensures high performance, scalability, and secure data management. The inclusion of performance analytics and adaptive assessment techniques allows users to track progress and improve systematically.Overall, the system offers a data-driven approach to programming education, supporting learners in achieving better proficiency while enabling effective and reliable skill evaluation.

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assessment systems, personalized learning, and performance analytics, making it highly relevant for AI-driven programming evaluation systems.

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