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CodeEdu- Code, Compile, Collaborate

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Abstract*— This research paper explores the development, functionality, and impact of CodeEdu, an AI-integrated, realtime collaborative platform for coding practice, online assessments, and technical interviews. Developed using the MERN stack with Socket.IO and WebRTC, it features a dynamic DSA problem-solving interface with support for C++, JavaScript, Python, and Java. CodeEdu integrates Google Gemini AI to offer error explanation, solution guidance, and intelligent hint generation. The platform's secure interview module includes real-time proctoring, ESC key tracking, email-based room access, and face-to-face interviews with video calling and live code sharing via sockets. Users can also upload custom problems for personalized practice. With responsive UI, real-time collaboration, and scalable architecture, CodeEdu benefits students, educators, and recruiters alike. Future enhancements include mobile support, code grading, and adaptive AI learning paths to meet evolving academic and industry demands.

1. INTRODUCTION

CodeEdu is an AI-integrated, real-time web platform designed to enhance DSA learning and streamline technical interviews. Traditional coding portals often lack AI support, real-time evaluations, and secure interview experiences, leading to disconnected workflows for learners and recruiters.

CodeEdu combines AI-powered coding assistance, interactive problem-solving, and secure assessment environments using modern technologies like Socket.IO, WebRTC, and the Gemini API. It features a multi-language code editor, dynamic hint generation, error explanation, and solution insights—all powered by AI. In addition, the platform enables custom problem creation and includes robust interview modules with full-screen proctoring and live coding interviews via video conferencing.

Built for students, educators, and interviewers, CodeEdu simplifies coding practice, personalized learning, and technical hiring. With scalable backend services and intelligent feedback mechanisms, it effectively bridges gaps in skill-building, collaboration, and recruitment workflows.

2. LITERATURE REVIEW

Z. Yang, H. Chen, R. S. Rosenthal (2019) – This paper explores the use of real-time web technologies to facilitate collaborative coding. It discusses the implementation of WebSockets and Socket.IO in supporting simultaneous code editing by multiple users, which has been effectively applied in CodeEdu's face-to-face interview module for live code sharing and interaction.

M. A. B. Dawood, M. S. Khan (2021) – This review highlights developments in online coding platforms with features such as real-time feedback, AI-powered assistance, and collaborative problem-solving. CodeEdu leverages these advancements to deliver dynamic hint generation, AI-driven solution explanation, and secure online assessments.

A. Kumar, P. Singh (2020) – This study offers a detailed look at the MERN stack's capabilities in building scalable web applications. CodeEdu is built entirely on this stack, utilizing MongoDB, Express.js, React.js, and Node.js to create a responsive, high-performance platform supporting live coding and real-time data flow.

3. PROPOSED SYSTEM

CodeEdu is an advanced, AI-powered web platform designed to transform coding education, technical assessments, and interview preparation. Developed using the MERN stack and enhanced by technologies like WebRTC and Socket.IO, it supports real-time code execution, collaborative learning, and dynamic interview environments. Its DSA practice module offers multi-language support, AI-integrated feedback, and user-defined problem creation.

Integrated with the Google Gemini API, CodeEdu delivers smart debugging, dynamic hint generation, and detailed solution explanations. Its interview module offers two modes: secure online coding assessments and face-to-face video interviews, complete with real-time proctoring, ESC-key detection, and live code sync. With seamless scalability, modular design, and dynamic AI interaction, CodeEdu equips learners, educators, and recruiters with a unified platform that bridges the gap between problem-solving practice and technical hiring.

Key Features:

Real-time coding with AI assistance: CodeEdu provides a real-time coding interface for solving DSA problems using languages like C++, JavaScript, Python, and Java. Users can write code, add inputs, and instantly view outputs. AI features like "Check Error," "Explain Solution," and "Get Hint" dynamically assist users during coding, improving learning and engagement.

Custom Problem Creation and Testing: The platform allows users to create custom coding problems through a structured folder system. These user-generated problems support the same real-time code execution, AI debugging, and explanation features, offering a personalized and flexible learning experience for both individuals and educators.

Secure Online Assessments: Interviewers can host online coding assessments by selecting questions and inviting candidates via email. The assessment interface enforces fullscreen mode, tracks ESC key exits, and eliminates violators. This ensures strict proctoring, preventing malpractice during time-bound evaluations.

Face-to-Face Interviews with Live Coding: In this mode, interviewers and candidates connect via video using WebRTC and PeerJS. Coding problems selected by interviewers appear live on the candidate's screen, with real-time collaborative code sharing using Socket.IO. Interviewers can monitor and assess solutions as they are written.

AI-Powered Debugging and Explanation: Using Google's Gemini API, CodeEdu helps users identify syntax and logical errors. It explains bugs contextually and provides hints or full solutions. These features support adaptive learning by guiding users based on their code and understanding level, improving clarity and retention.

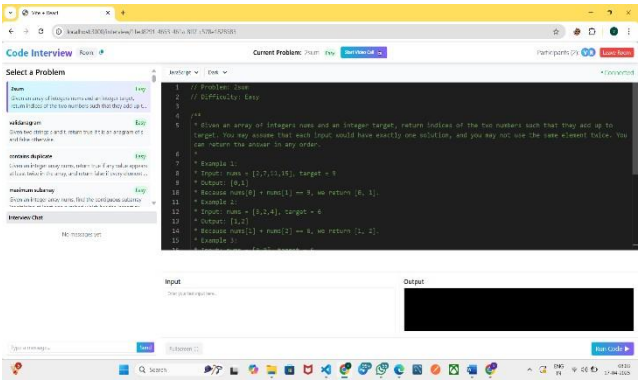
Scalable MERN-based Architecture: Built using the MERN stack with efficient socket integration, the system ensures real-time data flow and smooth performance. The backend uses optimized database queries and API architecture to handle concurrent users, while cloudbased deployment supports scalable, low-latency interactions across modules.

4. METHODOLOGY

CodeEdu follows an agile and modular development approach, ensuring a scalable, AI-integrated coding and interview platform. It includes a dynamic DSA coding interface, real-time collaborative interview modules, and AI-assisted learning using the Google Gemini API. The system's workflow features JWTbased authentication, real-time communication with Socket.IO, and video integration via WebRTC.

The platform enforces secure coding assessments through fullscreen monitoring and ESC key detection while offering Gemini AI–powered assistance for debugging, hints, and explanations. Its backend uses RESTful APIs and MongoDB to ensure data integrity and speed, while real-time updates maintain smooth user interaction.

1. **Agile Development Approach:** The CodeEdu platform was developed using an agile methodology to allow incremental feature integration, frequent testing, and user-driven refinements. The development lifecycle consisted of iterative sprints that included requirement gathering, UI/UX prototyping, module-based development, feedback integration, and testing. Each sprint added functional value to the system, enabling rapid progress and high adaptability to user needs. This ensured the platform evolved efficiently with stability and scalability at its core.
2. **Secure Technical Interview System:**To support reliable online technical interviews and assessments, CodeEdu integrates a secure environment that detects and responds to user behaviors. When candidates participate in assessments, the platform enforces fullscreen mode and listens for actions like ESC key presses or window switching. Any such activity leads to automatic disqualification to maintain fairness. During live interviews, video calling with real-time problem sharing ensures authenticity. The entire flow—from room creation and email invitation to answer submission—is structured for transparency and security.
3. **Optimized UI/UX with Real-Time Feedback:**The user interface is developed using React and Tailwind CSS, offering a clean and responsive layout. A multilanguage Monaco code editor supports real-time input, output, and AI-generated feedback. Users receive dynamic hints, detailed error messages, and solution explanations that foster effective learning and efficient problemsolving.
4. **Cross-Platform Compatibility and Expansion:**CodeEdu is fully functional on both desktop and mobile browsers, ensuring accessibility from various devices. The system is designed to be easily extendable into a Progressive Web App (PWA) for offline usage. Future updates will include native Android and iOS applications, enabling candidates to practice and participate in assessments from anywhere.



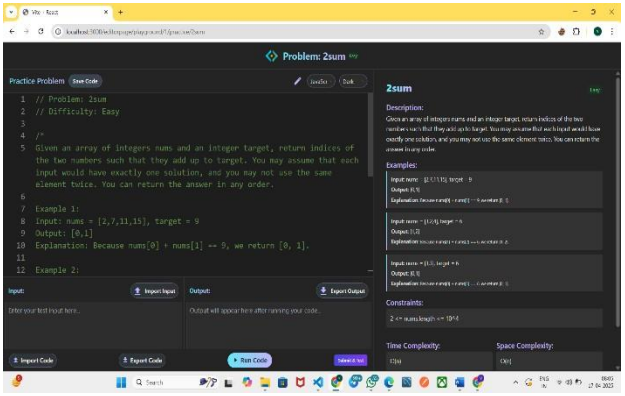


FIG 1: UI & DASHBOARD

5. **Secure Interview Dashboard:**Interviewers have access to a comprehensive dashboard where they can schedule interviews, select problems, and monitor candidates. Video communication is enabled via WebRTC, while real-time collaborative coding is managed using Socket.IO. The interviewer can view every code change instantly, assess performance, and interact directly with the candidate.

6. **AI-Based Skill Tracking and Assistance:**The platform is tightly integrated with the **Google Gemini API**, which provides AI-based debugging and smart assistance. When a user submits code, the AI examines the logic, syntax, and structure, and provides actionable feedback such as "check your loop conditions" or "missing base case." In addition, users can ask for hints or a detailed solution explanation. These interactions not only assist in correcting mistakes but also contribute to adaptive learning by guiding users based on their previous submissions and problemsolving patterns.

7. **High-Performance Backend Architecture:**The backend is built using Node.js and Express.js, communicating with a MongoDB database for storing user data, problems, and code submissions. RESTful APIs manage authentication, problem execution, and interview workflows. Real-time features use Socket.IO for syncing code and WebRTC for media streaming, ensuring quick and reliable system operations.

8. **Dynamic DSA Problem Creation and Execution:**Besides solving preloaded problems, users can create their own questions in a folder-based structure with descriptions, constraints, and examples. These problems can be compiled and executed directly in the code editor with the same AIdriven features, allowing educators and learners to personalize the learning environment.

9. **Structured Development Cycle:**The development cycle consisted of six distinct phases: initial system setup, DSA module integration, secure interview functionality, AI feature implementation, UI/UX refinement, and cloud deployment. Each phase focused on modularity and scalability, using tools like Vite, React, MongoDB, and third-party APIs to build a seamless and maintainable platform.

10. **Comprehensive Testing Strategy:** To ensure system reliability, CodeEdu employs unit tests to validate components, integration tests to verify module interactions, and user acceptance testing (UAT) for final validation. Security testing checks authentication, session control, and assessment protection, while performance tests confirm stability under multiple concurrent users.

11. **Multi-UserReal-TimeCoding Environment:**Using Socket.IO, the platform enables multiple users to interact in real time during live interviews. Code written by a candidate is instantly visible to the interviewer. This enables pair programming simulations and real-time evaluations, enhancing the accuracy and depth of the assessment process.

12. **AI-Powered Debugging and Learning Guidance:**Gemini AI enhances the learning experience by identifying errors in code and providing human-like responses. Whether it's a simple bug fix or an explanation of a complex logic error, the AI is capable of responding based on the context of both the problem and the user's code, creating a personalized learning path.

13. **Scalable and Secure Cloud Infrastructure:**The platform is deployed on scalable cloud architecture capable of handling concurrent users without performance drops. MongoDB ensures secure and efficient data storage, while WebRTC and PeerJS enable smooth video interactions. Load balancing and session caching optimize the response time and reduce downtime during peak usage.

14. Performance-Optimized System Design: Every

5. CONCLUSION

component of CodeEdu is optimized for speed and performance. Backend APIs are structured for fast response times, while the frontend uses lightweight libraries and bundling via Vite. The use of sockets and pre-cached queries helps maintain real-time interaction and reduces server overhead even during simultaneous sessions.

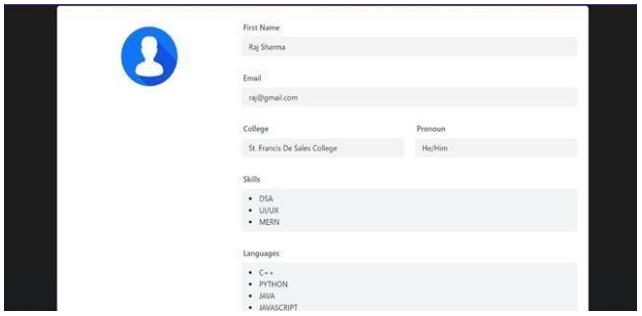


FIG 2: Login Page

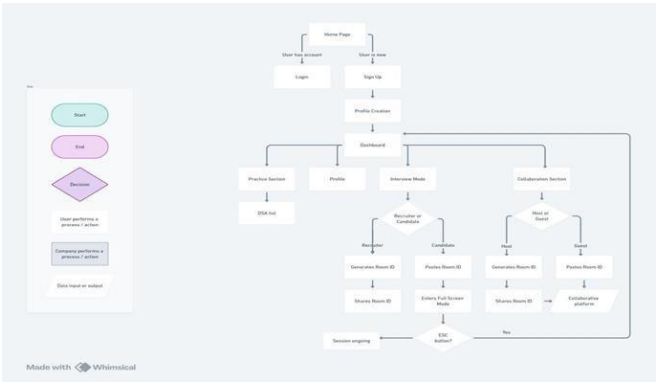


FIG 3: Control flow diagram

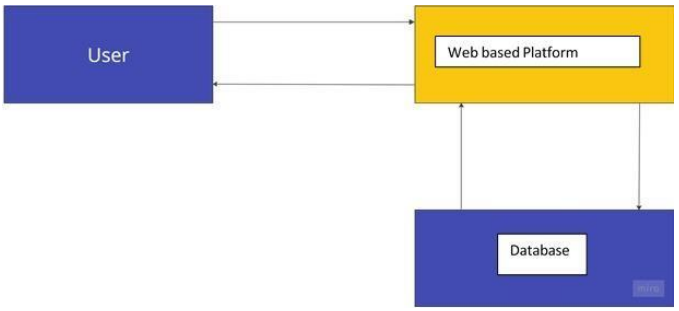


FIG 4: Context level diagram

The CodeEdu platform is designed to bridge the gap between real-time coding practice, AI-assisted learning, and secure technical interviews by unifying them into one scalable, end-toend system.

Unlike other platforms that isolate DSA practice, AI tools, or interview environments, CodeEdu integrates real-time multi-user code execution with **Socket.IO**, AI-powered debugging and explanations via **Google Gemini API**, and secure remote interviews using **WebRTC**, email-based room access, full-screen enforcement, and live code monitoring.

Additionally, the system includes support for custom problem creation, dynamic AI hinting, and real-time proctoring for coding assessments. It offers scalable infrastructure and AI-enhanced support, helping users improve problem-solving skills efficiently. CodeEdu enhances the preparation process for learners, while streamlining candidate evaluation for recruiters, making it a robust platform for modern coding education and hiring.

1. **Performance and Scalability Improvements:** CodeEdu has been architected to efficiently support concurrent users by utilizing real-time technologies like **Socket.IO** and **WebRTC**, ensuring smooth code collaboration and interview interactions. During internal testing, the platform demonstrated stable performance under high loads, with low latency across both coding and video sessions. Cloud infrastructure optimizations have reduced deployment costs while maintaining system reliability and availability, allowing smooth DSA execution and interview sessions at scale.

2. **AI Model Training Limitations:** Gemini API-based debugging uses pre-trained models which may not catch deeply nested or domain-specific logic errors. To improve accuracy, future updates aim to incorporate custom fine-tuned models trained on larger, problemspecific datasets for deeper context awareness.

3. **Scalability for Large-Scale Interviews:** While CodeEdu supports multiple simultaneous assessments and interviews, hosting thousands of parallel interview rooms will require improved dynamic resource allocation. Future updates will include advanced load balancing and multi-server orchestration for enterprisegrade reliability.

4. **Accessibility for Low-Bandwidth Users:** The platform's real-time features currently require a stable connection. Future plans include implementing offline code editing with sync-on-connect functionality, lightweight AI inference models, and reduced video call dependency to support users with limited bandwidth.

5. **Future AI and Mobile Expansion:** Upcoming updates include AI-based automated code grading, smarter error suggestions with user history tracking, and full mobile app development for Android and iOS. This will empower learners to practice coding and attend interviews on-the-go with full platform capabilities.

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