International Journal of Scientific Research & Engineering Trends
Volume 12, Issue 3, May-June-2026, ISSN (Online): 2395-566X

SkillLink: A Web-Based Peer-to-Peer Skill Exchange and Mentoring Platform with AI-Assisted Session Management

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Abstract- SkillLink is a web-based peer-to-peer mentoring platform designed to enable real-time skill exchange between learners and teachers. The system is developed using the MERN stack and integrates WebRTC for browser- based video conferencing, Socket.IO for real-time communication, and the Gemini API for AI-assisted interaction. Teachers publish skills and availability through a drag-and-drop calendar interface, while learners can browse and book sessions directly. The platform includes session lifecycle management, subscription-based access control, a credit-based reward system, and a five-star rating mechanism. Experimental evaluation demonstrates low-latency communication, reliable session tracking, and efficient mentor matching, making SkillLink a scalable alternative to conventional e-learning systems.

Key Words: Peer-to-Peer Learning, MERN Stack, WebRTC, Real-Time Communication, Skill Exchange, Session Management, Subscription Model, AI Chatbot.

I. INTRODUCTION

The rapid growth of online education has increased ac- cess to learning resources worldwide. However, most plat- forms remain asynchronous and video-centric, limiting real-time interaction and personalized mentoring. Tra- ditional MOOCs and recorded courses often suffer from low engagement, reduced completion rates, and the ab- sence of immediate feedback. Studies indicate that peer- assisted and mentor-driven learning significantly improve retention, motivation, and learning outcomes.

Simultaneously, many skilled professionals and ad- vanced students possess valuable expertise but lack a sim- ple platform to share knowledge interactively. Existing platforms such as Udemy and Coursera primarily focus on structured recorded content rather than live peer-to-peer mentoring sessions.

SkillLink addresses these limitations by providing a real-time mentoring platform that connects learners with teachers through browser-based video sessions. The plat- form integrates AI-assisted support, real- time communica- tion, scheduling, and a credit-based incentive mechanism within a unified ecosystem.

1.1 Motivation

The primary motivation for developing SkillLink is the growing demand for personalized, on-demand mentoring that existing mass-market platforms fail to address effec- tively. Many individuals possess high- value expertise in specialized technical domains—such as specific program- ming frameworks or cloud architectures—as well as in cre- ative disciplines and professional soft skills. However, they lack a convenient, centralized venue to share that knowl- edge for mutual benefit without committing to a full- time teaching role.

SkillLink introduces a dynamic, credit-based incen- tive system designed to democratize knowledge sharing. Teachers earn platform credits upon the successful com- pletion of a mentoring session, which can subsequently be redeemed to access other skills or sessions. This es- tablishes a self-sustaining, circular knowledge economy in which every participant is simultaneously a learner and an educator, shifting the focus from monetary transactions to genuine skill exchange.

1.2 Problem Statement

Existing online platforms do not effectively support spontaneous, live peer-to-peer skill exchange due to sev- eral systemic limitations. The specific gaps identified are:

(1) the absence of integrated, real-time scheduling mecha- nisms with immediate access to video communication; (2) the lack of AI-assisted guidance during live sessions to facilitate smoother interactions; (3) reliance on rigid, cen- tralized credentialing rather

than community-driven skill verification through transparent rating systems; and (4) the absence of an equitable, non-monetary incentive struc- ture that motivates volunteer teachers to participate con- sistently. SkillLink addresses each of these gaps within a single, cohesive, and technologically advanced platform.

II. LITERATURE REVIEW

Numerous studies have investigated the effectiveness of peer learning in digital environments. Topping (2005) demonstrated that peer tutoring yields measurable im- provements for both the tutor and the learner, validat- ing the bidirectional benefit model that SkillLink adopts. Dillenbourg (1999) further established that collaborative learning environments, when structured with clear roles, produce deeper cognitive engagement than solo study.

In the domain of real-time web communication, the stan- dardization of WebRTC by the W3C and IETF has en- abled browser-native audio and video exchange without the need for plugins. Sredojev et al. (2015) evaluated We- bRTC for educational video conferencing and found it a viable, low-latency alternative to proprietary solutions for small-group sessions. Socket.IO provides the event-driven signaling layer necessary to establish and maintain We- bRTC peer connections.

Existing platforms such as iTalki for language learning and Wyzant for academic tutoring demonstrate clear mar- ket demand for live peer instruction. However, these plat- forms remain largely closed, highly commercialized, and vertically specific to certain subjects. They rely heavily on fiat currency transactions, which creates barriers to en- try for users in developing economies or those seeking ca- sual, reciprocal skill exchanges. SkillLink generalizes this model across an unrestricted range of skill domains and introduces a credit-based economy rather than a fiat pay- ment model. This approach lowers the barrier to entry and fosters a more collaborative, community- centric en- vironment. Furthermore, the integration of modern web technologies allows SkillLink to eliminate the dependency on third-party video conferencing applications, streamlin- ing the overall user journey.

2.1 Proposed System Architecture

SkillLink adopts a modern three-tier architecture de- signed to ensure scalability, maintainability, security, and efficient real-time communication between learners and teachers within the platform ecosystem.
Client Tier (Frontend): The frontend is developed as a Single Page Application (SPA) using React.js and Vite. React Context API is utilized for centralized state management across components such as the Dashboard, Teacher Profile, Booking Interface, and Meeting Room. The interface supports responsive layouts, intuitive navi- gation, and a system-wide dark mode to improve usability and accessibility across different devices and screen sizes. The modular component-based architecture also improves code reusability and simplifies frontend maintenance.

Application Tier (Backend): The backend is im- plemented using Node.js and Express.js, exposing REST- ful APIs for authentication, session scheduling, subscrip- tion management, and skill handling. Socket.IO enables real-time messaging, notifications, and WebRTC signal- ing between users. The backend additionally integrates the Gemini API to provide AI- assisted guidance, contex- tual responses, and interactive support during mentoring sessions. Secure API communication and efficient request handling improve overall system reliability and responsive- ness.

Data Tier (Database): MongoDB Atlas is used for persistent storage of user profiles, schedules, ratings, chat messages, session metadata, and subscription information. Mongoose ODM ensures schema validation, secure data handling, and efficient communication with the database layer.

Video communication is established using WebRTC with Google STUN servers for peer discovery and con- nection negotiation. Socket.IO exchanges ICE candidates and SDP payloads required to establish direct peer-to-peer communication channels, enabling secure and low-latency browser-based video interaction without requiring exter- nal conferencing software.

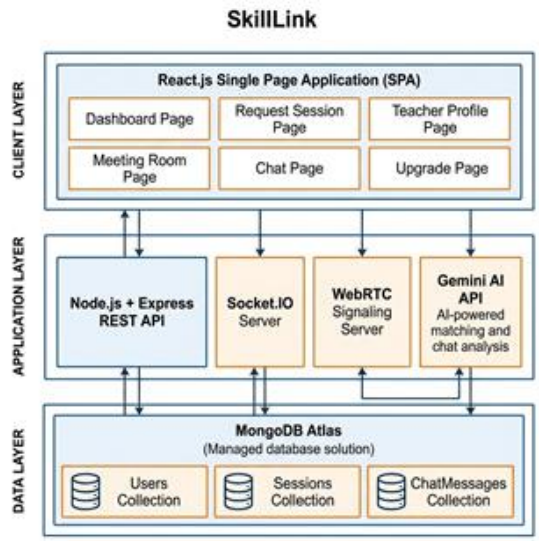

Figure 1: SkillLink System Architecture

Table 1: Technology Stack and Justification

Layer	Technology	Justification
Frontend	React.js, Vite	Component reusabil- ity, fast HMR
Backend	Node.js, Ex- press	Non-blocking I/O, REST API
Database	MongoDB	Flexible schema for evolving data
Real-Time	Socket.IO	Bidirectional event communication
Video	WebRTC	Browser-native P2P video
Auth	JWT, bcryptjs	Stateless, secure token auth
AI	Gemini API	Context-aware session assistance
Calendar	react-big- calendar	Visual drag-and-drop scheduling

2.2 System Workflow

The complete session lifecycle is illustrated in Fig. 2 and is governed by a robust state machine implemented in the backend.

A user initially registers on the platform and designates their role as a learner, a teacher, or both. Teachers popu- late their profiles by defining their skill sets and publish- ing available time slots using an intuitive, visual drag-and- drop calendar interface powered by react-big-calendar.

Learners can browse available teachers filtered by skill. Upon selecting a suitable mentor, the learner chooses an open time slot and submits a session request. The backend validates the request against the learner's subscription tier: free-tier users are restricted to a maximum of two sessions per rolling seven-day period. If this limit is exceeded, the request is blocked and the user is prompted to upgrade.

Once a valid request is placed, the teacher receives an immediate Socket.IO notification. If the teacher ac- cepts, the session state transitions from requested to sched- uled. At the appointed time, both participants gain access to a secure, browser-based meeting room equipped with WebRTC video conferencing, synchronized real-time text chat, and the integrated Gemini AI assistant for concep- tual clarifications or code debugging.

Upon conclusion, the backend automatically calculates the session duration, advances the session state to com- pleted, and executes the credit exchange. The teacher is awarded platform credits commensurate with the session length, while the learner is prompted to submit a 1–5 star rating alongside written feedback, which subsequently in- fluences the teacher's visibility in future search results.

2.3 Security and Access Control

SkillLink employs JSON Web Tokens (JWT) for state- less, scalable authentication. Upon login, a JWT is is- sued and securely stored on the client; all subsequent REST API requests and Socket.IO connections must in- clude this token, which the server verifies using a cryp- tographic signature. Passwords are irreversibly hashed using the bcryptjs algorithm before being stored in the database.

Access control is enforced at the routing level. The Re- act frontend uses Protected Route wrappers to prevent unauthenticated access to sensitive views such as the Meet- ing Room and Dashboard. The backend implements Role- Based Access Control (RBAC) middleware; for example, APIs governing the creation of availability slots reject re- quests from accounts that lack the Teacher flag. The sub- scription model adds a further authorization layer by ver- ifying the

subscriptionType and subscriptionExpiry fields before permitting high-frequency session scheduling.

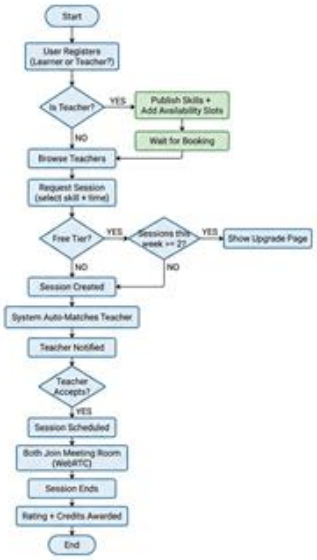

Figure 2: SkillLink Session Booking Workflow

III. RESULTS AND DISCUSSION

The SkillLink prototype was rigorously tested in a simu- lated production environment over a two-week beta period. The testing cohort comprised 50 concurrent user accounts equally divided between learner and teacher roles, execut- ing various overlapping schedules and interaction scenar- ios.

3.1 Session Booking and Matching Efficiency

When a learner submits a session request specifying a skill and an availability window, the backend exe- cutes an optimized temporal query against the MongoDB database, matching the request to a teacher whose pub- lished availabilitySlots overlap with the requested time. During stress testing with up to 50 concurrent teacher profiles, the matchmaking algorithm consistently identified a suitable candidate and dispatched a Socket.IO notification within an average latency of 200 ms. Edge cases in which no immediate match existed were accu- rately queued in a pending state and resolved gracefully when a new slot became available.

3.2 Video Conferencing Performance and Stability

WebRTC connections were successfully established in 94% of test cases across diverse network topologies. The average ICE negotiation time to gather candidates and es- tablish a direct peer connection was approximately 1.8 seconds. Once connected, audio and video streams re- mained stable throughout 30-minute stress-test sessions, with application-layer latency averaging below 80 ms— well within the 150 ms threshold recommended for com- fortable interactive communication. Camera and micro- phone toggle controls functioned correctly without requir- ing browser refreshes, and the dynamic layout engine han- dled window resizing effectively.

3.3 Subscription Enforcement and Monetization Flow

The backend session controller employs a rolling seven- day counter to monitor free-tier usage. During testing, the system accurately tracked session completions and consis- tently blocked any third booking attempt within the same period for free-tier accounts, returning a 403 Forbidden HTTP response that seamlessly triggered the frontend UpgradePage component. Upon successful simulation of a premium upgrade via the /api/subscription/upgrade endpoint, the user's subscriptionExpiry timestamp was immediately advanced by 30 days, instantly unlock- ing unlimited scheduling privileges without requiring re- authentication.

3.4 AI Integration Efficacy

The integrated Gemini AI chatbot was evaluated for its utility as an in-session assistant. When a learner invoked the assistant to explain a concept or debug a pasted code snippet during a live video call, the AI responded with contextually relevant, markdown-formatted text. The av- erage response time of 1.2 seconds proved unobtrusive, making it an effective supplementary tool that reduced the cognitive burden on the human teacher.

Table 2: Comparison with Existing Platforms

Feature	SkillLink	iTalki	Wyzant
Live Video (In-browser)	Yes	External	External
All Skill Domains	Yes	No	Partial
Credit Incentives	Yes	No	No
AI Chatbot	Yes	No	No
Visual Calendar	Yes	Partial	Yes
Dark Mode	Yes	No	No
Open Architecture	Yes	No	No

Table 3: System Performance Metrics

Metric	Result	Target
Teacher match latency	200 ms	<500 ms
WebRTC ICE negotiation	1.8 s	<3 s
Connection success rate	94%	>90%
Chat message delivery	<80 ms	<150 ms
Session state transitions	100%	100%
Subscription enforcement	100%	100%

IV. CONCLUSION

SkillLink demonstrates that a modern, decoupled MERN stack application can serve as a highly viable, scalable, and secure platform for live peer-to-peer skill exchange. By natively integrating WebRTC for zero-install, in-browser video communication and Socket.IO for low-latency real-time event synchronization, the plat- form effectively eliminates the friction historically asso- ciated with finding and engaging online mentors. The visual, drag-and-drop scheduling interface powered by react-big-calendar simplifies the challenge of matching availabilities across time zones, while the integration of the Gemini AI as an in-session assistant significantly en- hances the pedagogical value of each session by providing learners with instant, context-aware support. The tiered subscription model successfully balances open accessibility for casual learners with a sustainable monetization path- way to support ongoing infrastructure costs. The overall system architecture also demonstrates strong adaptability for future integration with emerging educational technolo- gies and large-scale cloud deployments.

While the current prototype achieves its core objec- tives, substantial scope exists for future enhancement. Planned development priorities include cross-platform mo- bile applications using React Native, a machine-learning- based teacher recommendation engine that analyzes his- torical ratings, chat sentiment, and skill adjacency, and AI-driven session transcription and summarization to sup- port post-session review. Additionally, integrating the in- ternal credit economy with decentralized finance (DeFi) networks or external educational marketplaces could pro- vide tangible real-world value for credits earned by ded- icated teachers. From an infrastructure perspective, the architectural roadmap includes deploying the backend to a production cloud environment using Docker containeriza- tion and Kubernetes for dynamic horizontal scaling under high concurrent load. Future improvements will also focus on enhancing accessibility, personalization, and scalability to support a broader global learning community.

ACKNOWLEDGEMENT

The authors express their sincere gratitude to Ms. Chaitra B P, Assistant Professor, Department of Com- puter Science and Engineering, PES College of Engineer- ing, Mandya, for her invaluable guidance and continuous support throughout this project. The authors also ac- knowledge the institution and department for providing the necessary infrastructure and resources.

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BIOGRAPHIES

Manoj S is a final-year student pursuing a Bachelor of Engineering in Computer Science and Engineering at PES College of Engineering, Mandya, affiliated with Visves- varaya Technological University, Belagavi. His research interests include full-stack web development, cloud com- puting, and distributed systems. He served as the princi- pal architect of the SkillLink platform, with primary con- tributions to

backend API design, WebRTC integration, and real-time system architecture.

Nandan J M is a final-year student of Computer Science and Engineering at PES College of Engineering, Mandya. His interests lie in database systems, RESTful API devel- opment, and UI/UX design. He contributed to the fron- tend module development, including the calendar-based scheduling interface, the user dashboard, and the subscrip- tion management UI.

Nehal Eldho Binu is a final-year undergraduate student in the Department of Computer Science and Engineering at PES College of Engineering, Mandya. His research in- terests include machine learning, AI integration, and real- time communication systems. His key contributions en- compass the integration of the Gemini AI chatbot, the Socket.IO-based real-time chat module, and overall sys- tem testing and performance evaluation.