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Communities of Practice : Learning, Meaning and Identity

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PREFACE

Learning is fundamentally a social process, shaped through participation, collaboration, and the shared construction of knowledge within communities. The concept of *Communities of Practice* has become increasingly significant in education, organizational development, professional training, and knowledge management, emphasizing how individuals develop expertise through meaningful engagement with others. *Communities of Practice: Learning, Meaning and Identity* explores these dimensions by presenting a systematic examination of collaborative learning environments and the design of technology-supported solutions that facilitate knowledge sharing and professional growth.

This book provides a structured progression from conceptual foundations to practical implementation. It begins with an introduction, motivation, objectives, and a comprehensive review of relevant literature that establishes the theoretical basis for the study. The subsequent chapters define the problem statement and describe the proposed system, followed by detailed project planning through calendars and Gantt charts. The volume further presents system analysis and design using data flow diagrams, use case diagrams, activity diagrams, class diagrams, sequence diagrams, and entity-relationship models, offering readers a clear understanding of the project's architecture and workflow.

The later chapters discuss system architecture, database design, implementation strategies, software modules, hardware and software requirements, algorithms, testing methodologies, and evaluation results. Together, these sections demonstrate the practical application of theoretical concepts in developing an effective collaborative learning platform while highlighting best practices in software engineering and project management.

The editors express their sincere appreciation to the authors, reviewers, and publishing team whose dedication has made this volume possible. We hope this book serves as a valuable resource for students, researchers, educators, software developers, and professionals interested in collaborative learning, knowledge management, educational technology, and system development, inspiring further innovation and meaningful contributions to the advancement of learning communities.

- Editors

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ABSTRACT

SkillSwap is a P2P learning network that was conceptualized for creating a collaborative setting whereby learners share skills and knowledge in an environment void of any form of financial transaction. SkillSwap follows a peer-to-peer learning approach where students teach and learn from one another by sharing skills, experiences, and knowledge. The platform encourages collaboration, communication, and continuous skill development without involving monetary transactions. In essence, the platform offers numerous skill sets such as programming, graphic design, communication, content writing, among others, which students need in their quest for professional growth. The proposed project is anchored on the provision of several components, which include user authentication, skill management, skill matching intelligence, session management, real-time communications, and reputation/feedback system. Learners will be able to identify suitable peers in terms of their interests, skills, and availability, hence promoting knowledge transfer and collaboration. Ultimately, the implementation of the proposed project is aimed at increasing students' employability skills, fostering self-improvement, improving peer networks, as well as promoting sustainability in education and learning.

CHAPTER 1

INTRODUCTION

SkillSwap is an online educational resource that was designed to enable students to swap skills among themselves by adopting the principle of peer-to-peer learning. While conventional educational frameworks rely heavily on professors and training programs, SkillSwap allows students to utilize their existing skills to help others while simultaneously learning new skills from peers within the platform. By connecting learners and skilled individuals based on their interests and expertise, the system encourages collaboration, knowledge exchange, and continuous personal and professional development without the need for monetary transactions.

Motivation

With the swift development of technological innovations, continuous learning and training have become essential skills among students. Nevertheless, students often face problems such as an inability to acquire affordable learning materials, access suitable tutors, and get individualized instruction. Learning websites usually offer one-sided delivery of educational content, thus failing to provide any collaborative learning space for students to practice knowledge acquisition. Many students also have useful skills, yet they cannot find a convenient platform where they could share their knowledge and experience and learn something new in exchange. In response to these issues, we decided to develop SkillSwap, which will allow students to engage in active peer-to-peer learning using a time swap concept. Thus, the learning system will not only promote collaborative learning practices but also facilitate knowledge exchange between peers.

Objectives

SkillSwap seeks to design a peer-learning network which will enable students to exchange skills without involving monetary transactions, fostering an open and collaborative learning environment. This system will be easy to use and will have a good response rate for users seeking to acquire knowledge or teach others skills. The system will be time banking, where hours spent learning are used instead of money.

This system will be equipped with real-time communication options such as video conferencing and screen sharing among others, for the purposes of conducting interactive sessions. Security systems for authenticating and providing feedback will also be put in place to enhance trust. Intelligent algorithms will be applied to match students and

teachers in the most appropriate way depending on various factors. Learning capabilities are to be verified through artificial intelligence assessment models.

Fundamental Technical Goals

- For implementing a safe and reliable user login/registration mechanism with OTP authentication and JSON Web Token (JWT) Authentication.
- For designing a dynamic skill profile creation and management system where users can add their teaching skills as well as learning skills.
- For implementing an artificial intelligence (AI)-based skill verification process via testing.
- For implementing a Match Compatibility Score (MCS) algorithm which will help in making peer as well as mentor suggestions.
- For providing real-time communication functionalities like chat, notifications, and collaborative learning sessions.
- For maintaining a feedback/reputation system for enhancing platform credibility.
- For designing a scalable backend server architecture using Spring Boot & MySQL database.

Design and Performance Goals

- Designing an interactive and responsive web interface to be used by both teachers and learners.
- Automating the process of verifying, matching, and recommending skills with minimal human involvement.
- Ensuring speedy and accurate results by using multi-factor scoring algorithm.
- Guaranteeing secure and reliable transfer of data within various components of the system.
- Supporting notifications, sessions, and interaction with other users.
- Facilitating engagement with personalized learning suggestions.

Application Objectives

- For the creation of an interactive peer-to-peer learning environment for promoting knowledge exchange.
- For enabling the discovery of appropriate learning partners and mentors on the basis of their recognized skills.
- For fostering the professional development of individuals and career progression.

- For the provision of a reliable platform using skill validation and reputation management features.

Vision for Ongoing Research

- To increase the accuracy of recommendations using advanced methods in Artificial Intelligence and Machine Learning.
- To provide recommendations to users based on their learning and performance in an adaptive manner.
- To incorporate advanced analytics to monitor learning and engagement.
- To provide additional features related to group learning, project collaboration, and community-based learning.
- To experiment with the application of large language models (LLMs) in providing personalized tutoring services.

CHAPTER 2

LITERATURE SURVEY

Recent developments in educational technology have led to the rise of online learning platforms, mentoring systems, and collaborative learning communities. These platforms have made learning resources widely accessible, allowing users to gain knowledge across various fields. However, many existing systems mainly focus on instructor-led learning and paid educational services, which limits opportunities for direct peer interaction and knowledge sharing.

Research in peer-to-peer learning shows that collaborative learning environments can improve knowledge retention, communication skills, and learner engagement. Studies indicate that students often learn more effectively when they actively participate in teaching and discussing concepts with their peers. Various mentoring platforms and learning communities have successfully facilitated knowledge sharing, but many struggle with efficient methods for verifying skills and matching users based on compatibility.

Recommendation systems have been widely adopted to improve user experiences by offering personalized suggestions. In educational applications, these systems help learners find relevant courses, resources, and mentors. Improved recommendation techniques that consider user preferences, experience levels, and behavioral patterns have been shown to boost learning outcomes and user satisfaction.

Artificial Intelligence has further changed modern learning environments by enabling adaptive learning, intelligent tutoring systems, automated assessments, and personalized recommendations. AI technologies can analyze user behavior and provide customized learning experiences, making educational platforms more effective and scalable.

Despite these advancements, there is still a need for a platform that combines peer-to-peer learning, skill verification, intelligent matching, real-time communication, and reputation management within a single ecosystem. SkillSwap fills this gap by offering an environment that supports collaborative learning and skill exchange among students.

Study of Peer-to-Peer Learning Platforms

Peer-to-peer learning platforms encourage users with different skills to share knowledge. Research shows that learners tend to get better results when they participate in knowledge exchange instead of just consuming content. Current platforms like mentoring networks and knowledge-sharing communities allow users to connect, work together, and learn from one another. However, many of these systems do not have smart matching processes or

ways to verify skills. This leads to uneven learning experiences and challenges in finding qualified mentors.

Study of Recommendation Systems

Recommendation systems are commonly used to link users with relevant content, products, or people. Different methods, including content-based filtering, collaborative filtering, and hybrid recommendation systems, have been used to improve recommendation accuracy.

In educational settings, recommendation systems assist learners in finding appropriate courses, mentors, and learning resources. Research shows that considering user preferences, expertise levels, and behavior patterns greatly enhances recommendation quality and user satisfaction.

Study of Skill Matching Algorithms

Identifying appropriate learning partners heavily depends on the algorithm you use to match them on skill set. Traditional matching methods mainly use keyword comparison as well as profile similarities to find a match. Recent studies show that matching people using a multi-factor model based upon factors such as proficiency level, availability, mentor/mentee reputation, credentials, and the goals each has for their business can yield better results than using one factor alone. Using a weighted scoring method is an effective way to rank potential matches for professional networking and mentoring systems using multiple criteria.

Artificial Intelligence in Education

Transforming modern education through personalized learning experiences is possible with the use of artificial intelligence. AI technologies that can be implemented include automated assessment, intelligent tutoring systems, adaptive learning paths, or recommendation systems. Recent advancements in large language models (LLMs) such as the google groq.api have also made it possible to automatically generate assessment questions, study materials, and personalized feedback. All of these technologies will result in a significant amount of time reduced for creating assessments while increasing the scalability and quality of the learning process.

Reputation and Trust Management Systems

There is a lot of research suggesting that trust is a key element of online communities and in particular, online learning communities. One of the primary mechanisms for establishing a sense of trust or credibility for a user is to have a mechanism to evaluate their past

performance, reputation systems provide that mechanism through rating users, leaving feedback, and by understanding their previous participation history within the community. The research suggests that reputation-based mechanisms increase the reliability of the platform, foster positive user behavior, and enhance user confidence in choosing mentors or learning partners for collaborative learning activities. E-commerce, freelancing, and educational platforms have all adopted feedback-driven reputation systems to assist users in making informed decisions.

Real-Time Communication Technologies

Success in collaborative learning will largely be based on effective communication among users. New technologies such as WebRTC, WebSocket, and real-time messaging systems can facilitate real-time communication among users. Studies show that when learners interact synchronously via video, audio, or chat, their engagement levels, knowledge retention levels, and quality of collaboration all improve immensely. Therefore, real-time communication tools are quickly becoming an essential part of any online learning ecosystem.

Research Gap

The review found that most of today's learning systems serve mainly to provide course content with only limited mentor support and hardly offer any training using the completed courses. However, very few systems combine all four of the identified functions within one platform with built-in methods to validate skill levels.

The combination of automated assessment, automatically matching or pairing learners to others, collaboratively interacting in real time, and acquiring feedback to establish a reputation system all create a comprehensive learning experience but are not found within any current platforms.

Motivation for Proposed System

To address the limitations identified in existing systems, the proposed "SkillSwap: Peer-to-Peer Learning Platform" introduces:

- AI-based skill verification through intelligent assessments.
- Multi-factor Match Compatibility Score (MCS) calculation.
- Personalized peer and mentor recommendations.
- Real-time communication and collaboration features.
- Feedback-driven reputation management.
- Bidirectional skill exchange between learners and teachers.

The proposed system aims to create a reliable, intelligent, and scalable learning ecosystem that improves skill development, collaboration, and knowledge sharing among users.

Sr. No.	Title	Author	Year	Description
1	Impact of Peer Mentoring on Freshmen Engineering Students	Dan Budny, Cheryl Paul & Beth Bateman Newborg	2010	Describes a freshmen seminar and small-group peer-mentored classes for engineering first-year students; shows how peer mentoring supports transition and ongoing success.
2	Peer-Led Team Learning in Mathematics Courses for Freshmen Engineering Students	John R. Reisel, Marissa Jablonski, Ethan Munson & Hossein Hosseini	2014	Reports on peer-led team learning (PLTL) in freshman engineering mathematics courses and shows that increased participation correlates with improved outcomes.
3	Required Peer-Cooperative Learning Improves Retention of STEM Majors	Matthew Salomone & Thomas Kling	2017	Discusses a system-wide peer-cooperative learning programme across STEM departments and its effect on student retention.
4.	Enhancing Academic Feedback Systems with Deep Learning and Ensemble Methods	Hemant Sharma & Hiren Joshi	2019	Presents a system for enhancing academic feedback using deep learning and ensemble methods. It processes student responses and performance data using neural architectures for better analysis and automation.

CHAPTER 3

PROPOSED SYSTEM

Problem Statement

A lot of students experience problems acquiring new skills because of their lack of finances, limited access to mentors, and therefore not having access to personalized learning opportunities. Most learning platforms will charge you a subscription fee and/or predominantly focus on the delivery of content instead of allowing students to learn collaboratively through the consumption of the content. Additionally, many learners experience difficulty in locating a suitable mentor or peer who shares their individual interests, availability, and learning goals. There are currently no systems available to assist learners with skill exchanges, thus reducing the availability of opportunities for mutual learning and knowledge transfer. As such, there is a need for the development of a secure, accessible, and collaborative digital platform that will allow learners to teach and learn from other peers through collaborative peer-to-peer learning, thus fostering a continuous culture of learning and personal development environment.

Proposed System

SkillSwap is a website where people can learn from each other. It is like a place where students can exchange skills and knowledge without paying money. The platform enables users to share their skills and learn from others through peer-to-peer interactions. Students can connect with suitable learning partners based on their interests, expertise, and learning goals.

SkillSwap has a lot of features that make it easy to use. People can make profiles. Say what they want to teach and what they want to learn. They can also find people who want to learn the same things they do. The website is safe. People can talk to each other in real time. To make sure people have experiences SkillSwap has a system where people can rate each other after they learn something. This helps people trust each other. It makes the community a good place to be. SkillSwap is made with technology so it can handle a lot of users. The main goal of SkillSwap is to help people share knowledge and work together. It wants to create a place where people can keep learning and growing. This can help people get jobs and make connections with others in their field. It is like a network of people who want to learn and help each other. SkillSwap is not just for classrooms it is for anyone who wants to keep learning.

People can use SkillSwap to learn skills and meet other people who like the same things. It is a way to learn something new and make friends at the same time. SkillSwap is a place for people who want to learn and teach others. It is easy to use. It is free. SkillSwap is a website that helps people learn from each other. It is a great resource, for anyone who wants to keep learning.

Time-Banking Model

SkillSwap follows a peer-to-peer learning model where students can teach and learn from one another through direct interaction. Users can create profiles, list their skills, and connect with suitable learning partners based on their interests and expertise. The platform encourages knowledge sharing, collaboration, and lifelong learning by connecting students with peers who can help them develop new skills and enhance existing ones.

Competency Verification

Before a student can offer to teach any skill they have to pass a test for that skill. This test is made up of 15 choice questions. The student needs to get least 10 out of 15 questions right to pass the test. That is like getting 67 percent of the questions. This way we can be sure that only students who really know what they are doing can teach the skill. This helps to make sure that the students who are teaching are actually good at the skill so the other students can learn from them. The skill that the student wants to teach is what the test is about so it is a good way to check if the student is competent, in that skill.

Bidirectional Skill Matching Engine

The core innovation of SkillSwap is its proprietary matching algorithm. Unlike simple filter-based matching, the engine computes a 100-point compatibility score for each potential learning partner based on seven weighted factors. The engine explicitly prioritizes perfect bidirectional swaps (you teach me X, I teach you Y) over one-sided arrangements, using a Mutual Swap.

Integrated Learning Environment

Once matched users have sessions in SkillSwaps virtual teaching room. This room is powered by WebRTC. Lets users do live video calls. They can share screens use a whiteboard with various tools like a pen, eraser, shapes and text. There is also a chat feature for talking during the session.

All these tools are, in one place so users do not need to switch between applications. The virtual teaching room has everything users need for a learning session.

Reputation and Accountability

After each session, each participant rates the other (from 1-star to 5-star) and leaves written feedback or comments about their experience. These ratings all feed into a matching algorithm so that the best teachers naturally come to the top of the match results while creating a quality self-regulating ecology. The proposed system will include the following functionalities:

User Registration and Secure Login Authentication

- Skill Profile Creation/Management
- AI-Based Skill Testing (Verification Process)
- Intelligent Peer-to-Peer Matching
- Match Compatibility Score (MCS) Calculation
- Manage Session Requests/Scheduling
- Real-Time Chat and Communication
- Notifications/Reminders
- Feedback/Reputation Management Id's
- Personalized Learning Recommendations

The proposed SkillSwap platform is designed to facilitate greater access to knowledge; promote collaborative learning; reduce barriers between skill developments; and establish a trusted community that efficiently facilitates the ability of users to provide expertise and learn from one another.

CHAPTER 4

PROJECT PLAN

Calendar

Phase	Duration	Key Activities	Deliverables
Phase 1: Requirement Analysis	Week 1	Problem identification, feature selection, literature survey, requirement gathering	Requirement Specification Document, Feature List
Phase 2: System Design	Week 2	Database design, system architecture, ER diagram, UML diagrams	Architecture Diagram, ER Diagram, UML Diagrams, Wireframes
Phase 3: Backend Development	Weeks 3–4	User authentication, profile management, skill exchange APIs, database integration	Functional APIs, Database Schema
Phase 4: Recommendation Module Development	Week 4	Skill matching logic, recommendation feature, testing	Recommendation Module
Phase 5: Frontend Development	Weeks 4–5	User interface development, responsive design, API integration	Complete UI Screens, Integrated Frontend
Phase 6: Communication Feature Integration	Week 5	Chat feature, notifications, peer interaction functionality	Functional Communication Module
Phase 7: Testing & Bug Fixing	Week 6	Unit testing, integration testing, debugging, user acceptance testing	Tested Application, Bug Reports
Phase 8: Performance Optimization	Week 7	Database optimization, API optimization, security improvements	Optimized System, Performance Report
Phase 9: Documentation & Final Submission	Weeks 8–9	Project report writing, API documentation, user manual, presentation preparation	Final Project Report, User Manual, Presentation

Gantt Chart

The Gantt chart below illustrates the week-by-week timeline for each project phase. Blue-filled cells indicate active work periods for that phase.

Phase / Activity	W1	W2	W3	W4	W5	W6	W7	W8	W9
Requirement Analysis									
System Design									
Backend Development									
AI Module Development									
Frontend Development									
WebRTC Integration									
Integration & Testing									
Performance Optimization									
Documentation & Report									

Figure 1: Gantt Chart– SkillSwap Project Timeline (W1–W9)

CHAPTER 5

DESIGN

Dataflow Diagram

A Data Flow Diagram (DFD) is alternatively known as a bubble chart. Bubble charts can represent systems in either of two basic ways; they can show us the inputs which enter into a system, what processing occurs to the inputs, and finally what output is produced from a process. The SkillSwap Peer-to-Peer Learning Platform DFD graphically depicts how information moves between user interfaces, backend servers, databases, artificial intelligence services, and the match-making engine.

Level 0 DFD

The Level 0 DFD represents the SkillSwap System as one complete process; The inputs from the learner or teacher to the SkillSwap system include the following: (i) the user's registration information, (ii) skills listed by the user, (iii) available time slots based on the user's availability, and (iv) a user's responses to tests. Additionally, the outputs from the SkillSwap system (to either a learner or teacher) can include the following: (i) a match between the user's profile and (ii) confirmation of the session being arranged between the two users via email or text message while providing (iii) notification to the user that verification of the skill that they will use to conduct the session with the matched

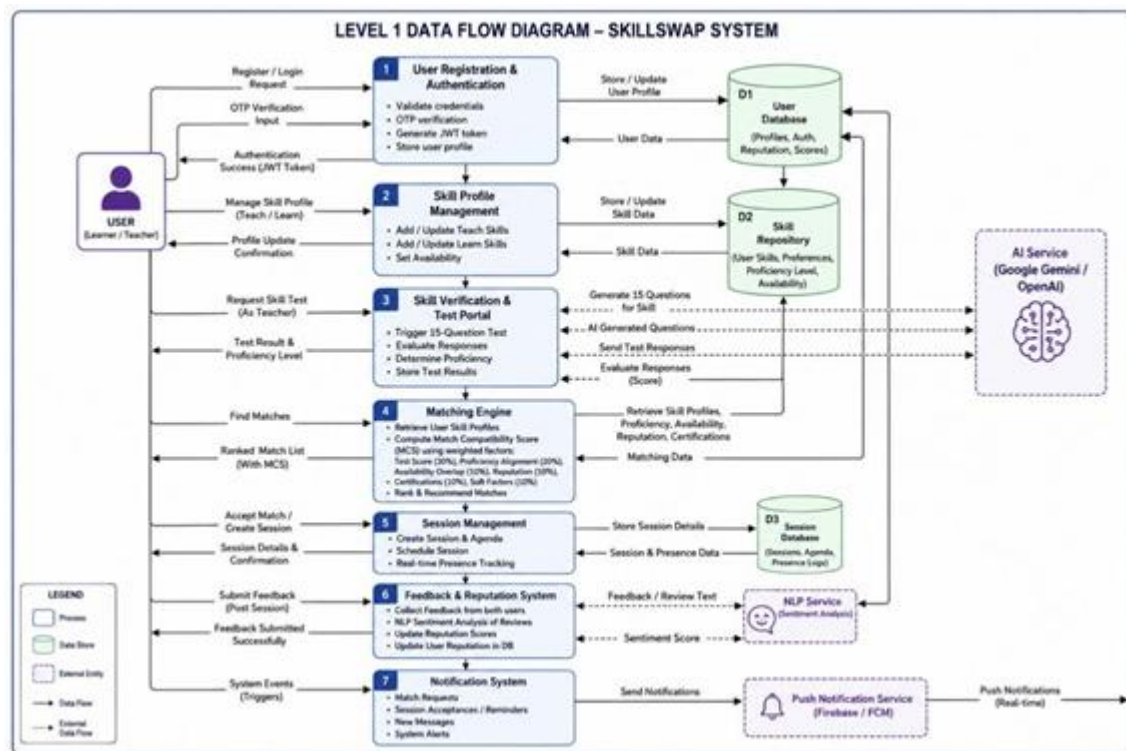


Figure 2: Data Flow Diagram of SkillSwap Platform

Use Case Diagram

Use Case Diagrams play a crucial role in defining system requirements and specify how the system should behave in UML notation. A Use Case Diagram explains the high-level functions and scope of a system. It also details how the different actors interact with the system.

In the SkillSwap Use Case Diagram, the following are considered as Actors:

- Registered User (Learner/Teacher): This is the primary Actor who registers to use the site, and creates a profile; takes the Skills Verification Tests; browses for matches with a registered user; sends and receives session requests; chats with a registered user; and submits post-session feedback about skills and the session.
- Admin: Admin is responsible for managing the static question bank; monitoring activity on the platform; and resolving disputes that have been reported.
- AI Service (e.g. Google Groq API / OpenAI): The AI service is considered an external actor as it generates skill-based assessment questions in real-time and performs sentiment analysis on the feedback provided.

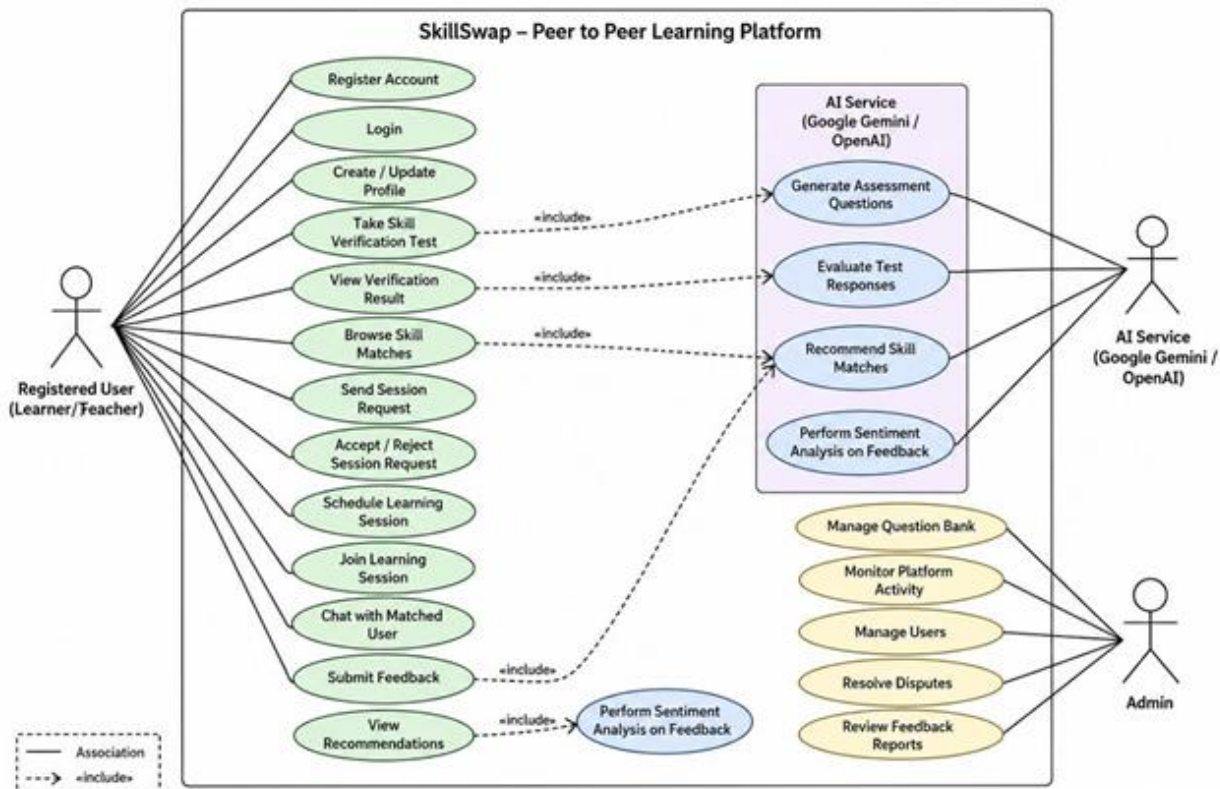


Figure 3: Use Case Diagram of SkillSwap Platform

Use Case Examples:

Use Case	Actor	Description
Register / Login	Registered User	User signs up with email, verifies via OTP, and logs in using JWT-secured tokens.
Create/Edit Skill Profile	Registered User	User lists skills to teach and learn, sets proficiency levels, and updates availability.
Take Skill Test	Registered User	User attempts a 15-question AI-generated or static test to become a verified teacher for a skill.
Browse Matches	Registered User	System displays ranked compatible peers based on the Match Compatibility Score (MCS).
Send / Accept Session Request	Registered User	User initiates a swap request; the matched user can accept or reject via the dashboard.
Real-Time Chat	Registered User	Users exchange messages to coordinate session logistics.
Submit Feedback	Registered User	Post-session star rating and written review are submitted and analyzed by AI sentiment engine.
Generate AI Questions	AI Service	AI is prompted to create 15 high-order questions for a given skill at HARD difficulty.
Manage Question Bank	Admin	Admin uploads or edits static fallback questions for each skill category.

Activity Diagram

An activity diagram is another essential UML diagram for describing the system's dynamic elements. An activity diagram is essentially a flowchart that shows how one activity leads to another. The action might be referred to as a system operation. Activity diagrams are used in SkillSwap to model the workflow of two critical processes: skill verification and session booking.

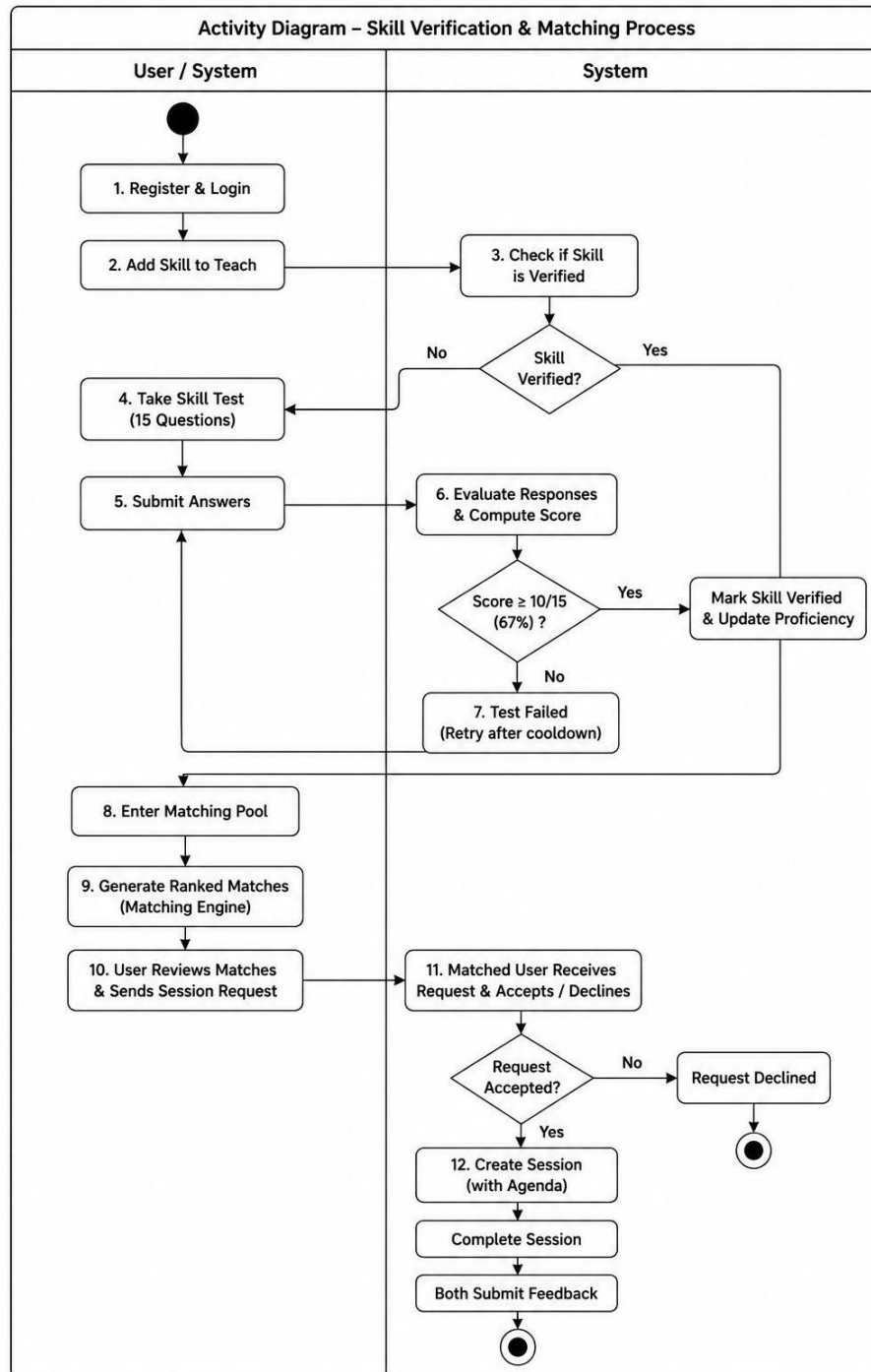


Figure 4: Activity Diagram of SkillSwap Platform

Data Flow Diagram (DFD)

The primary class in the system is the User class, which stores information such as user ID, name, email, password, role, reputation score, and profile details. Each user can possess multiple skills, participate in learning sessions, exchange messages, receive notifications, and provide feedback. The Skill class maintains information about teaching and learning skills, including skill name, category, proficiency level, and description. Users are associated

with one or more skills through profile management. The Skill Verification class manages assessment tests, stores test scores, and determines proficiency levels. It ensures that users are qualified before teaching a particular skill. The Session class handles learning session requests, scheduling, status tracking, and session agendas. It acts as a connection between learners and teachers during knowledge exchange.

The Message class supports real-time communication by storing chat messages exchanged between users. It maintains sender, receiver, content, and timestamp information.

The Feedback class records ratings and reviews submitted after session completion. This information contributes to user reputation and future matching recommendations.

The Notification class manages alerts and reminders related to session requests, confirmations, chat messages, and system announcements.

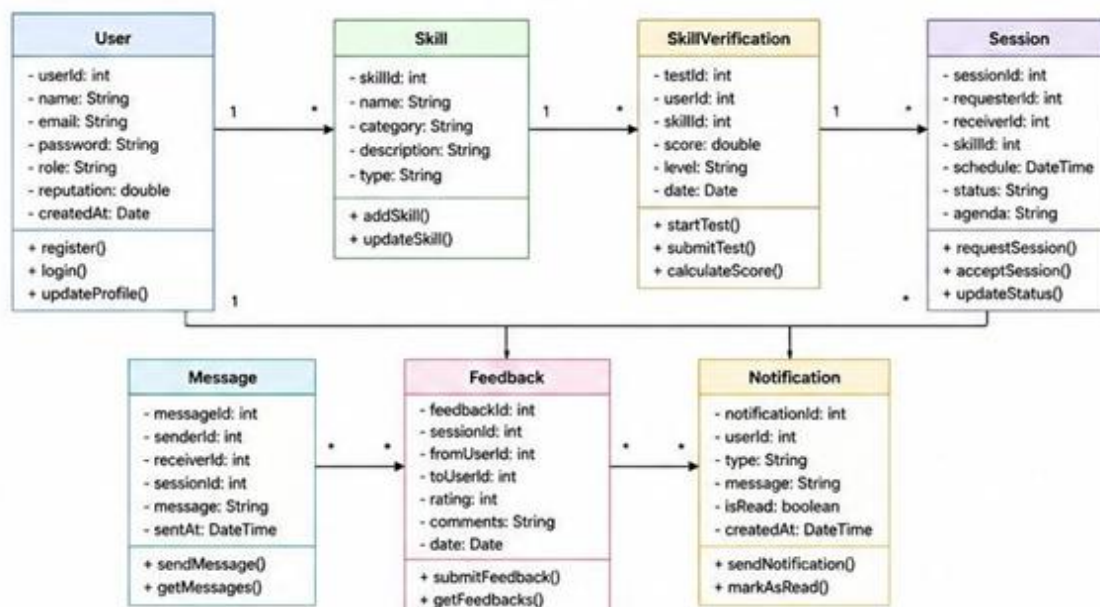


Figure 5: Class Diagram of SkillSwap Platform

Sequence Diagram

A sequence diagram is a type of interaction diagram that illustrates the interactions between a group of objects and the order in which they occur. Software engineers and business analysts use these diagrams to comprehend the specifications for a new system or to describe an existing process. The sequence diagram for SkillSwap models the end-to-end flow of a session request from initiation to confirmation.

Entity Relationship (ER) Diagram

The ER Diagram represents the database structure of the SkillSwap platform and shows the relationships between different entities such as User, Skill, Skill Verification, Session, Message, Feedback, and Notification. It helps in organizing and managing data efficiently

while maintaining data integrity. The diagram illustrates how users interact with skills, sessions, feedback, and communication modules within the system.

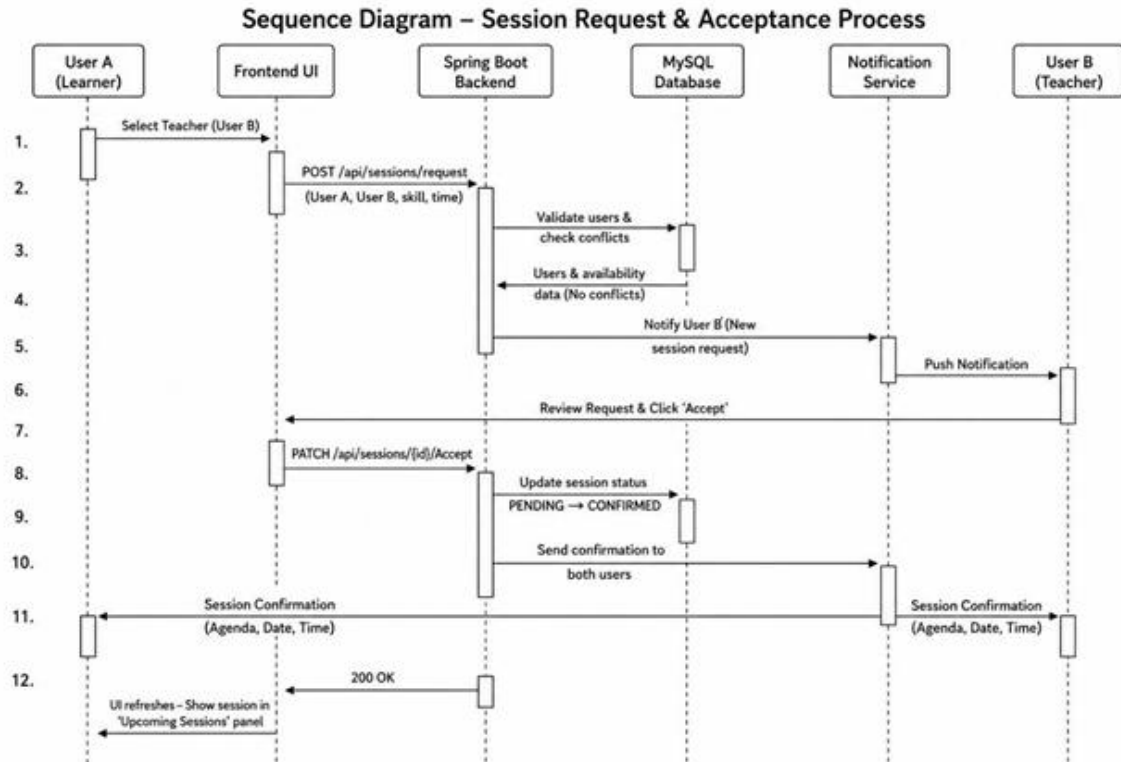


Figure 6: Sequence Diagram

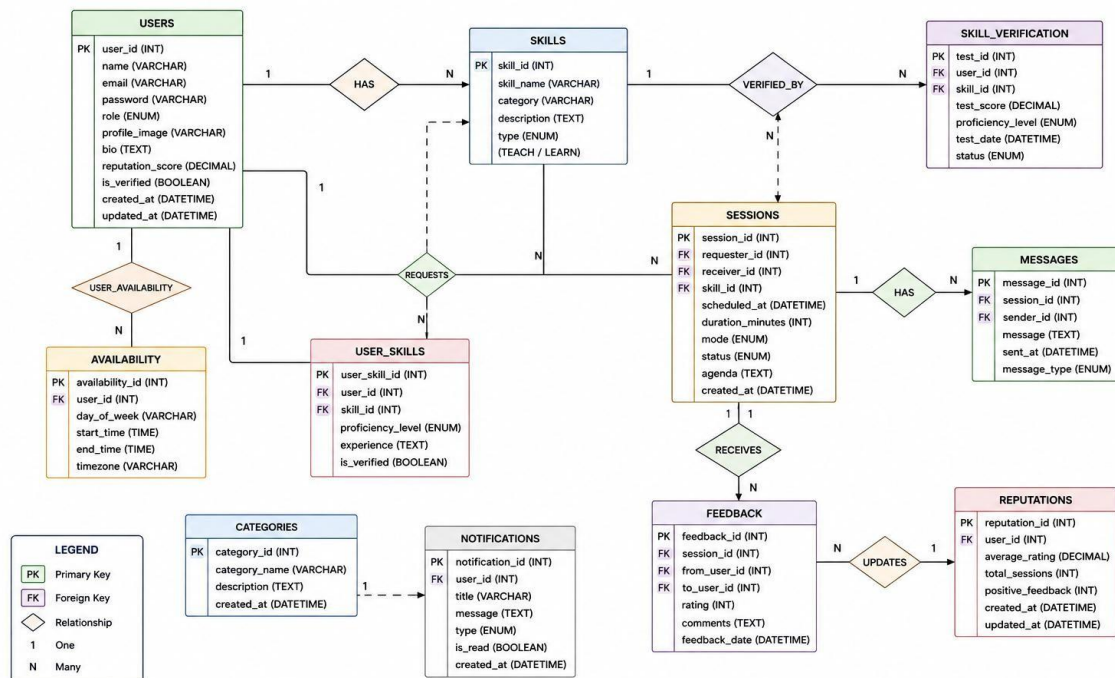


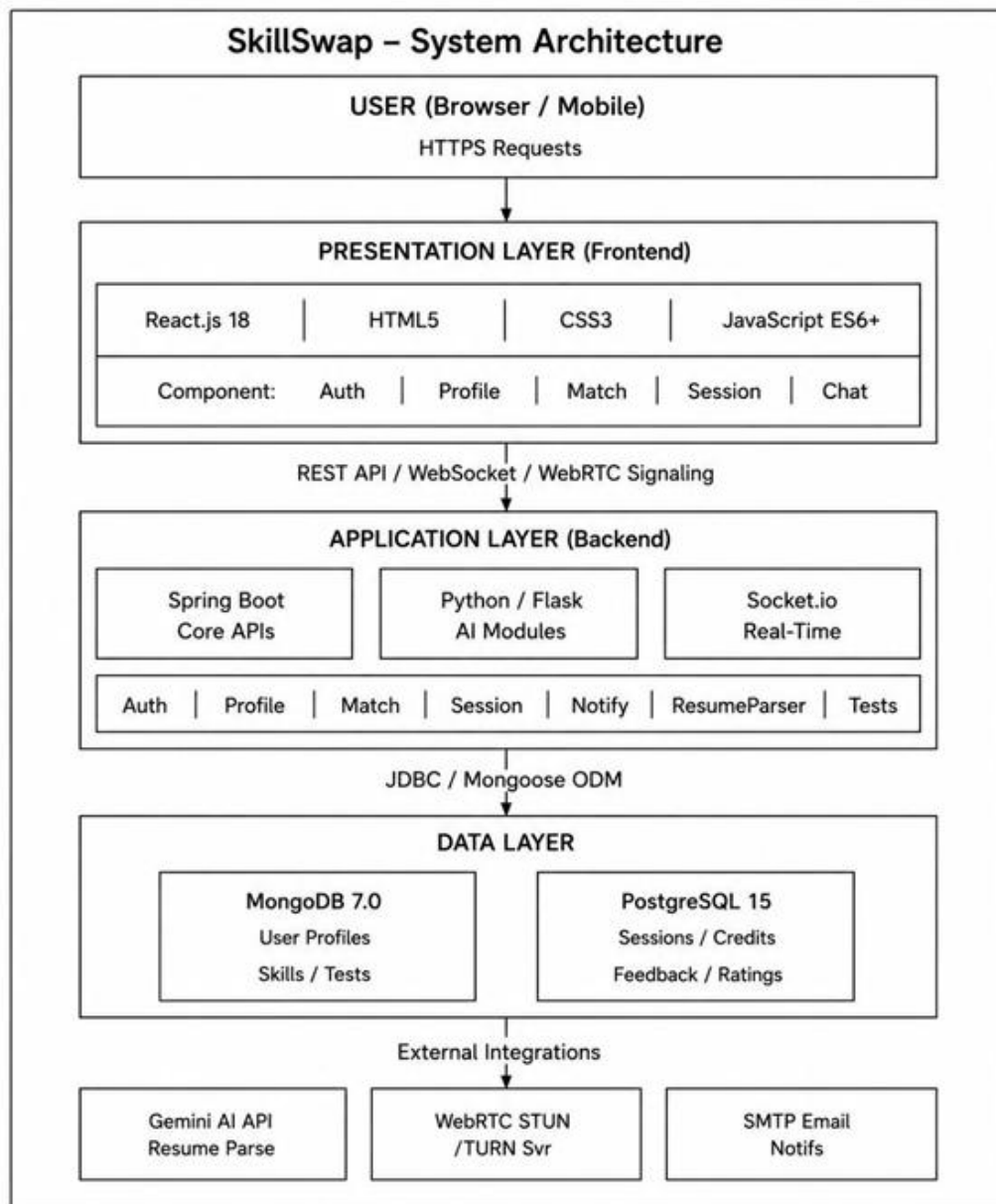
Figure 7: ER Diagram

CHAPTER 6

SYSTEM ARCHITECTURE AND PROPOSED METHODOLOGY

Overview – Three-Tier Architecture

SkillSwap follows a classic three-tier (N-tier) web application architecture that separates concerns into three distinct layers: the Presentation Layer (Frontend), the Application Layer (Backend), and the Data Layer (Database). This separation enables independent scaling, maintenance, and deployment of each tier.



Data Layer (Database Design)

SkillSwap uses a polyglot persistence strategy. Postgresql stores semi-structured, document-oriented data (user profiles, skills, sessions). Postgresql stores relational, transactional data (time ledger, audit logs, session ratings).

Collection/ Table	Database	Key Fields
users	Postgresql	id, name, email (unique), passwordHash, role, profilePicURL, bio, socialLinks, availabilitySchedule, createdAt
skills	Postgresql	_id, userId (ref), skillName, type (TEACH/LEARN), proficiencyLevel, learningStyle, testScore, certIds[], isVerified
certifications	Postgresql	_id, userId (ref), skillName, issuerName, issueDate, verificationURL, source (uploaded/parsed)
assessments	Postgresql	_id, userId (ref), skillName, questions[], answers[], score, passed (bool), attemptedAt, nextAttemptAllowed
matches	Postgresql	_id, requestorId (ref), candidateId (ref), skillOffered, skillWanted, compatibilityScore, swapType (PERFECT/PARTIAL), explanation, status, createdAt
sessions	Postgresql	_id, matchId (ref), tutorId (ref), learnerId (ref), skill, scheduledAt, startedAt, endedAt, durationMinutes, status, roomToken
feedback	Postgresql	id, sessionId (ref), raterId, ratedUserId, starRating (1-5), reviewText, submittedAt
notifications	Postgresql	_id, userId (ref), type, title, message, isRead, createdAt, relatedEntityId

CHAPTER 7

PROJECT IMPLEMENTATION

The "SkillSwap: AI-Powered Peer-to-Peer Learning Platform" is developed using a modular architecture where each module performs a specific operation related to user management, skill exchange, matching, communication, and feedback processing. The major modules of the system are described below.

List of Modules

The "SkillSwap: AI-Powered Peer-to-Peer Learning Platform" is developed using a modular architecture in which each module performs a specific function related to user management, skill exchange, intelligent matching, communication, and feedback processing. The major modules of the system are described below.

User Registration and Authentication Module

This module is responsible for user onboarding and secure access to the platform. It allows users to register, log in, and manage their accounts. The module implements OTP verification and JWT-based authentication to ensure secure access and session management. It also supports profile creation and account updates.

Skill Profile Management Module

This module enables users to create and manage their skill profiles. Users can specify the skills they are willing to teach as well as the skills they wish to learn. The module also allows users to manage availability schedules, learning preferences, and profile information. The collected data serves as input for the matching engine.

Skill Verification and Assessment Module

The Skill Verification Module ensures the credibility of users who wish to teach specific skills. It generates skill-based assessments through AI-generated or static question banks. Users must complete a verification test, after which their responses are evaluated automatically. Based on performance, proficiency levels such as Beginner, Intermediate, Advanced, and Expert are assigned.

AI-Based Matching Engine

This module acts as the core intelligence of the SkillSwap platform. It analyzes user profiles, verified skills, proficiency levels, availability schedules, certifications, reputation scores, and learning preferences. Using these parameters, the system computes a Match Compatibility Score (MCS) and generates ranked recommendations of suitable learning partners.

Session Management Module

The Session Management Module handles the complete lifecycle of learning sessions. Users can send and receive session requests, schedule learning sessions, define agendas, and manage participation. The module also tracks session status from request creation to successful completion.

Real-Time Communication Module

This module facilitates interaction between learners and teachers. It provides one-to-one chat functionality and supports WebRTC-based audio and video communication. Real-time messaging, presence tracking, and collaborative learning features help users communicate effectively during learning sessions.

Feedback and Reputation Module

The Feedback and Reputation Module collects ratings and reviews after the completion of learning sessions. It analyzes user feedback, updates reputation scores, and maintains historical performance records. These reputation scores contribute to future matching decisions and improve overall platform reliability.

Notification Module

This module manages all platform notifications and alerts. Users receive notifications for session requests, session confirmations, reminders, chat messages, and important system announcements. The notification system helps users stay informed about platform activities in real time.

Database Management Module

The Database Management Module is responsible for storing and managing all platform data. It maintains user profiles, skill repositories, verification results, session records, chat information, feedback, ratings, and reputation data. The module ensures secure, organized, and efficient data management.

Administration Module

The Administration Module provides system monitoring and management capabilities. Administrators can monitor platform activities, manage user accounts, resolve disputes, handle reported issues, manage question banks, and configure system settings. This module ensures smooth platform operation and governance.

PROCESSOR / COMPUTING SYSTEM

- Handles user authentication, session management, and skill matching operations.
- Executes AI-based question generation and sentiment analysis services.

- Supports real-time communication through WebSocket and WebRTC technologies.
- Ensures smooth performance of backend APIs and database transactions.

Storage Device

- The storage system is used for maintaining user profiles, skills, sessions, and feedback records.
- Stores user profile information and skill data.
- Maintains verification test results and proficiency levels.
- Stores session schedules, chat records, and feedback history.
- Supports secure storage of platform-related information.

Input Device

- Keyboard and mouse are used for navigation and interaction.
- Supports profile creation, skill management, and session scheduling.
- Enables users to participate in assessments and submit feedback.

Display Monitor

- Displays user profiles and matched learning partners.
- Shows verification test interfaces and results.
- Displays session schedules, notifications, and feedback reports
- Enhances user experience through an interactive web interface.

Software Tools

i. Spring Boot

- Develops RESTful APIs for platform functionality.
- Handles authentication, session management, and business logic.
- Integrates with databases and AI services.
- Provides scalability and security for enterprise-level applications.

ii. React.js

- React.js is used for frontend development.
- Provides an interactive and responsive user interface.
- Supports profile management, matching dashboards, and session screens.
- Enables seamless communication with backend APIs.
- Improves user experience through component-based architecture.

iii. MySQL

- MySQL is used as the primary relational database.

- Stores user profiles, sessions, ratings, and feedback.
- Maintains platform integrity through structured relationships.
- Supports efficient querying and data retrieval.

iv. JUnit 5

- JUnit 5 is used for testing backend components.
- Performs unit testing of APIs and services.
- Ensures reliability and correctness of application logic.
- Helps identify and resolve defects during development.

v. WebSocket & WebRTC

- Used for real-time communication features.
- Enables instant messaging between users.
- Supports live learning sessions and collaboration.
- Provides low-latency communication channels.

vi. Groq API AI API

- Used for intelligent content generation and analysis.
- Generates skill verification questions dynamically.
- Performs sentiment analysis on user feedback.
- Supports personalized recommendations and matching improvements.

Technologies Used

i. Artificial Intelligence (AI)

Artificial Intelligence enhances platform intelligence and automation.

- Generates dynamic skill verification assessments.
- Performs sentiment analysis on user feedback.
- Improves recommendation quality and matching accuracy.
- Enables personalized learning experiences.

ii. Natural Language Processing (NLP) NLP is used for analyzing textual feedback.

- Evaluates user reviews and comments.
- Determines sentiment polarity and intensity.
- Contributes to reputation score calculations.
- Improves quality assessment of learning sessions.

iii. Real-Time Communication Technology

- Real-time technologies enable instant collaboration.

- Supports chat and messaging features.
- Enables session coordination and interaction.
- Provides real-time status and presence tracking.

iv. JWT Authentication

- JSON Web Token (JWT) technology provides secure access control.
- Supports secure user authentication.
- Protects APIs from unauthorized access.
- Enables session management across the platform.

v. Data Processing & Analytics

- Data processing techniques support matching and recommendations.
- Analyze user skills and learning preferences.
- Process test results and reputation scores.
- Generate compatibility rankings and recommendations.

vi. Cloud-Based AI Services

- Cloud AI services improve system intelligence.
- Generate skill assessment questions.
- Analyze user behavior and feedback.
- Provide scalable AI-driven functionality.

Algorithm Details

The SkillSwap system uses an algorithm that is AI-assisted and weighted in order to create compatible partners for users of the SkillSwap platform (footnote 3). In order to determine the Match Compatibility Score for each user pair, the algorithm will analyze and evaluate user data such as the user's skill set, verification score, availability, user reputation, user certifications, and user preferences.

Step 1: User Registration & Profile Creation

- Users register on the platform and create profiles.
- Add skills they can teach.
- Add skills they want to learn.
- Set availability schedules and preferences.

Step 2: Skill Verification

- Before teaching a skill, users must complete a verification test.
- A 15-question assessment is generated.

- Questions may be retrieved from static banks or generated using AI.
- Test responses are evaluated automatically.

Step 3: Proficiency Level Assignment

- Based on test performance:
- Beginner
- Intermediate
- Advanced
- Expert

Step 4: Data Collection for Matching The system gathers:

- Verification scores
- Skill levels
- Availability schedules
- Reputation ratings
- Certifications
- Learning preferences

Step 5: Match Compatibility Score (MCS) Calculation

The Matching Engine computes MCS using weighted factors:

Factor	Weight
Skill Verification Score	30%
Proficiency Alignment	20%
Goal Alignment	10%
Availability Overlap	10%
Reputation Score	10%
Certifications	10%
Soft Factors	10%

The final score ranges from 0.0 to 1.0.

Step 6: Match Recommendation

- The system ranks users according to MCS.
- Displays best learning partners.
- Supports peer-learning and mentor-learning scenarios.
- Provides personalized recommendations. Step 7: Session Scheduling
- Users send and accept learning requests.

- Session agenda is created.
- Notifications are sent to both participants.
- Session details are stored in the database.

Step 8: Feedback & Reputation Update

- After session completion:
- Both users submit feedback.
- NLP-based sentiment analysis evaluates comments.
- Reputation scores are updated.
- Future matching results are improved.

Step 9: Continuous Learning Recommendations The recommendation engine analyzes:

- User clicks
- Session completions
- Feedback trends
- Learning preference

CHAPTER 8

SOFTWARE TESTING

Types of Testing

i. Unit Testing

Each module of the SkillSwap platform is tested independently to ensure correct functionality.

- User Registration and Authentication Module testing.
- Skill Profile Management Module testing.
- Skill Verification Test Module testing.
- Match Compatibility Score (MCS) calculation testing.
- Session Management and Notification Module testing.

ii. Integration Testing

Integration testing verifies proper communication among different modules of the system.

- Frontend and Backend API integration.
- Backend and MySQL database integration.
- AI Question Generation service integration.
- Notification service integration.
- Session Management and Matching Engine integration.
- Authentication and authorization flow validation.

iii. System Testing

System testing validates the complete functionality of the SkillSwap platform as a whole.

- User registration and login process.
- Skill profile creation and modification.
- Skill verification test execution.
- Match recommendation generation.
- Session request and acceptance workflow.
- Chat and notification functionality.
- Feedback submission and reputation updates.

iv. Performance Testing

Performance testing evaluates system efficiency under different workloads.

- Match generation response time.
- API response time measurement.

- Database query performance.
- Concurrent user session handling.

v. Security Testing

Security testing ensures protection of user data and system resources.

- JWT token validation.
- User authentication and authorization testing.
- Password encryption verification.
- API access control testing.
- Prevention of unauthorized session access.
- Input validation and SQL injection protection.

vi. Reliability Testing

Reliability testing verifies continuous and stable system operation.

- Long-duration session management testing.
- Continuous database transaction testing.
- Notification delivery reliability.
- AI service fallback mechanism testing.
- System recovery from temporary failures.

vii. User Acceptance Testing (UAT)

User Acceptance Testing validates the platform from the end-user perspective.

- Learners successfully find suitable teachers.
- Teachers complete skill verification tests.
- Users schedule and complete learning sessions.
- Feedback and reputation mechanisms function correctly.
- User interface is easy to navigate and understand.
- Overall platform usability meets
- Project objectives.

Test Cases and Results

This test matrix outlines critical verification checkpoints for the application's core functionality. It covers foundational security via authentication, automated workflow validation through skill verification and the matching engine, and real-time user engagement tracking via session management, instant notifications, and the feedback reputation loop, ensuring a reliable end-to-end user experience.

Test Case ID	Module	Test Scenario	Expected Result
TC01	Authentication	Valid Login	User logged in successfully
TC02	Authentication	Invalid Password	Error message displayed
TC03	Skill Verification	Score $\geq 10/15$	Skill marked Verified
TC04	Skill Verification	Score $< 10/15$	Retry message displayed
TC05	Matching Engine	Generate Matches	Ranked matches displayed
TC06	Session Management	Accept Session Request	Session status becomes CONFIRMED
TC07	Notifications	New Session Request	Notification received
TC08	Feedback Module	Submit Feedback	Reputation score updated

CHAPTER 9

RESULT AND DISCUSSION

The SkillSwap System is a working, example of an Artificial Intelligence (AI) supported, peer to peer, learning platform that supports the exchange of skills between teachers and learners. A SkillSwap comprises: user authentication; verification of skills; intelligent matching; session management; real time communications; and, cheque and balances on performance, creating an effective ecosystem through which people can learn from one another.

With the SkillSwap System, users can register for the system; create a profile for each skill in their possession; verify their skills via testing; identify a mutual learner; book a session with that learner; and, learn from each other using structured methods for learning (e.g. a lesson plan). The use of AI has enhanced several features of the SkillSwap system, including the efficiency of matching users with common learning objectives, making recommendations on each user's performance to other users, and analysing the performance of the user using performance based measures.

Key Results

- Successful implementation of secure user registration and JWT-based authentication.
- Efficient management of user profiles, teaching skills, and learning interests.
- Successful implementation of AI-assisted skill verification tests for validating user expertise.
- Accurate generation of Match Compatibility Scores (MCS) using multiple weighted factors.
- Intelligent recommendation of suitable learning partners through the Matching Engine.
- Real-time communication support through chat and session coordination features.
- Automated notification system for session requests, confirmations, and reminders.
- Effective feedback and reputation management system that improves future matching quality.
- Improved learning opportunities through structured peer-to-peer knowledge exchange.

Discussion

Due to using web technologies in a modern manner, AI technologies, and the intelligent matching algorithm that was built into system, it operates at a high level of efficiency; this is accomplished by using an additional verification module, called the "Verification Module", which is used to verify users' qualifications for specific skill areas in order to improve the overall quality of learning sessions among users. The weighted Matching Engine uses a combination of verification score, proficiencies, availability overlaps, reputations, certifications, and users' behavioral preferences in order to identify reliable matches between two or more users through a recommendation process.

Some of the component features of the proposed SkillSwap system will include: Creation of questions and performing sentiment analyses (all completely automated), therefore requiring less manual effort. These features plus the inclusion of real-time communication services, notifications, or any combination thereof will increase user interaction and collaboration.

- Promotes collaborative peer-to-peer learning rather than one-way knowledge delivery.
- Uses verified skill assessments to improve trust and learning quality.
- Provides intelligent and personalized matching recommendations.
- Reduces the effort required to find suitable learning partners.
- Supports both peer learning and mentor-based learning models.
- Encourages continuous skill development through feedback and reputation systems.
- Enhances user engagement through real-time communication and structured learning sessions.

The developed platform successfully achieves its objective of creating an intelligent, scalable, and user-friendly skill-sharing ecosystem that connects learners and teachers while ensuring quality, credibility, and effective knowledge exchange.

GUI Results



Figure 8: Wedpage Overview

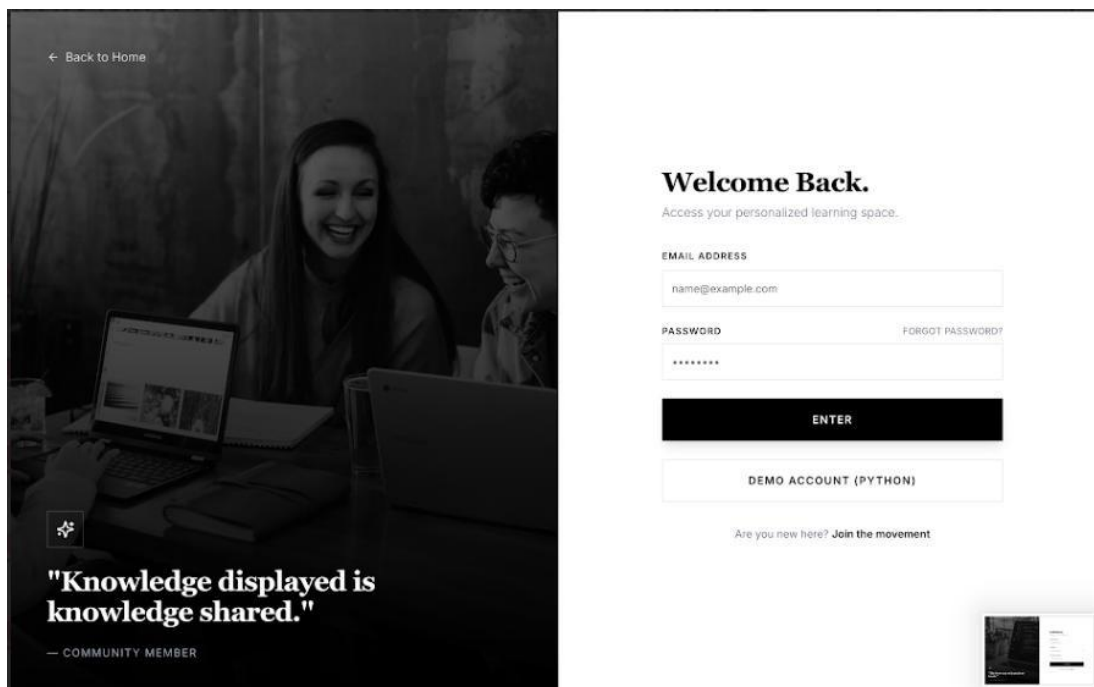


Figure 9: Login page

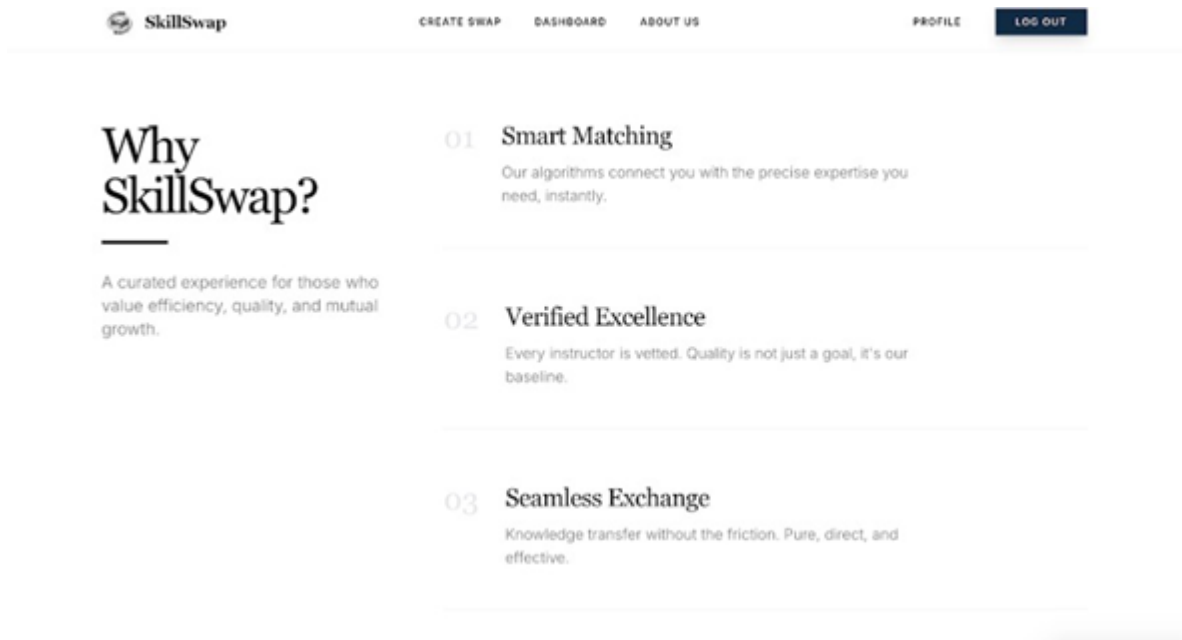


Figure 10: Dashboard

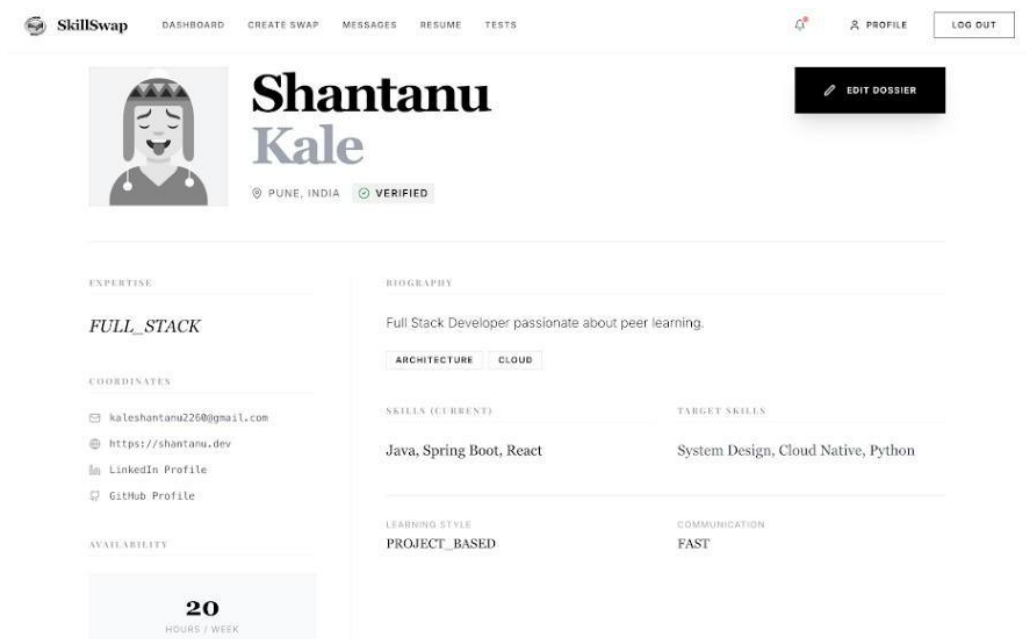


Figure 11: User Profile

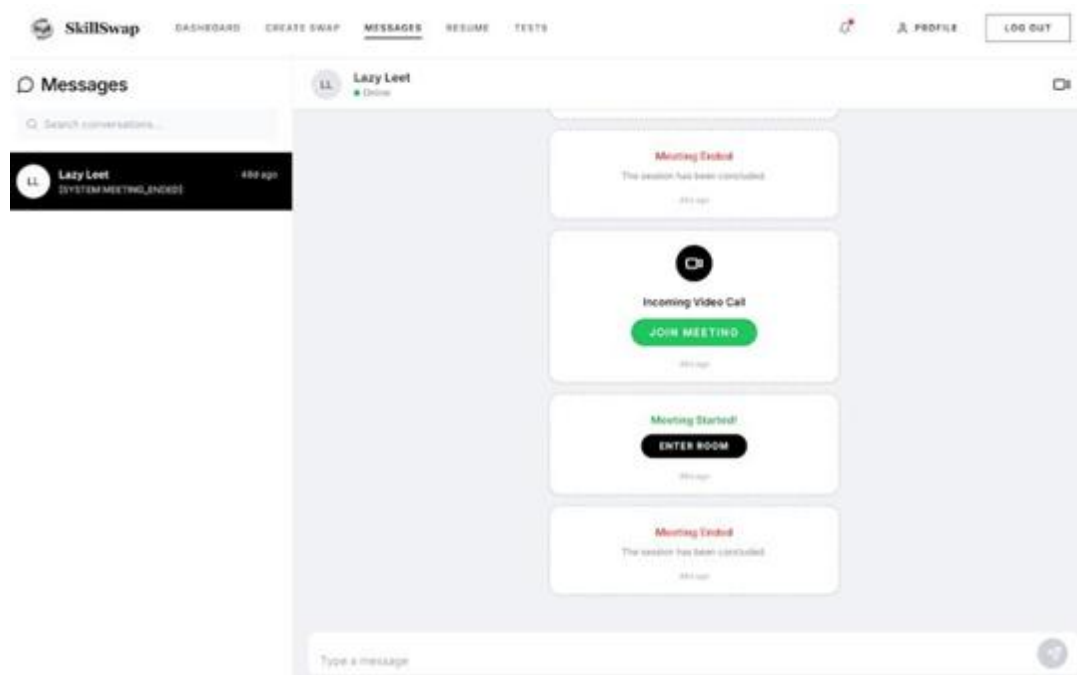


Figure 12: Meet Dashboard

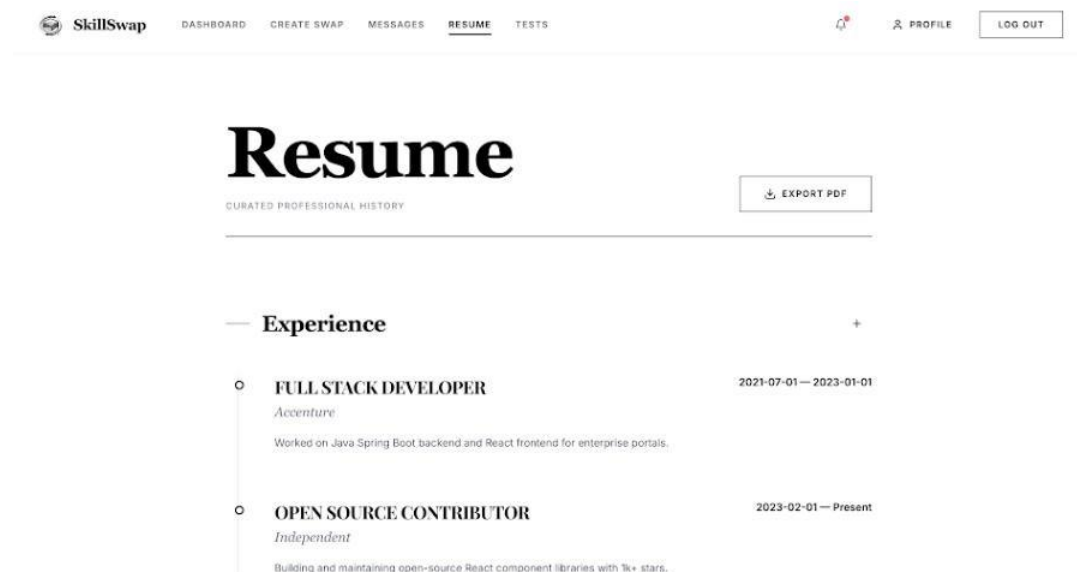


Figure 13: Resume Portal

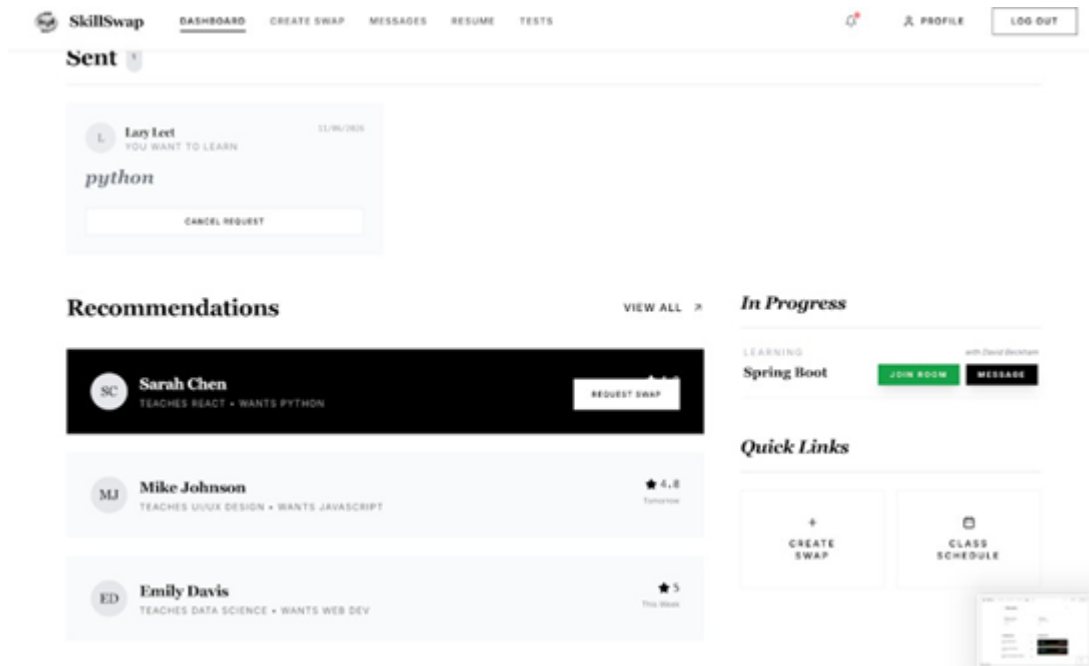


Figure 14: Recommendation Portal

CHAPTER 10

OTHER SPECIFICATIONS

Advantages

- The system provides an intelligent and efficient platform for peer-to-peer skill exchange and collaborative learning.
- AI-powered skill verification ensures that users possess adequate knowledge before teaching a skill.
- The weighted Matching Engine improves the quality of recommendations by considering multiple factors such as skill proficiency, verification scores, reputation, availability, and certifications.
- The platform supports both peer learning and mentor-based learning models, increasing learning opportunities for users.
- Real-time communication and session management features facilitate seamless interaction between learners and teachers.
- Automated notifications improve user engagement and ensure timely participation in learning sessions.
- The feedback and reputation system promotes trust, credibility, and continuous improvement among users.
- The system reduces the effort and time required to find suitable learning partners.
- AI-generated assessments and sentiment analysis automate evaluation processes and enhance platform intelligence.
- The web-based architecture provides accessibility from different devices and locations.

Limitations

- The effectiveness of the matching process depends on the accuracy of user-provided profile information and skill preferences.
- AI-generated assessment questions may occasionally require manual review to ensure relevance and difficulty consistency.
- The quality of recommendations depends on the availability of active users with compatible skills and schedules.
- Real-time communication features require stable internet connectivity for optimal performance.

- Sentiment analysis results may not always fully capture the context or intent of user feedback
- New users with limited activity history may initially receive less accurate recommendations due to insufficient data.
- The platform currently focuses on skill exchange and does not support formal certification or accreditation programs.
- High user traffic may require additional infrastructure and scaling mechanisms to maintain performance.

Applications

- Educational institutions can use the platform to encourage collaborative learning and knowledge sharing among students.
- Professional communities can utilize the system for skill development, mentoring, and career growth.
- Corporate organizations can implement the platform for employee training, upskilling, and internal knowledge transfer.
- Online learning communities can use the system to connect learners and experts across different domains.
- Freelancers and professionals can exchange technical and non-technical skills to enhance their expertise.
- Training centers and coaching institutes can leverage the platform to facilitate peer-assisted learning programs.
- Community organizations can use the system to promote skill development and lifelong learning initiatives.
- The platform can support career development by connecting learners with experienced mentors and subject matter experts.
- Research organizations can analyze learning patterns, user interactions, and recommendation effectiveness for educational studies.

CHAPTER 11

CONCLUSION

SkillSwap is all about dealing with an issue that's hurting a lot of people's education in the modern world: unequal access to quality opportunities to learn skills. SkillSwap levels the playing field for students from different economic backgrounds by offering a barter-like system based on exchanging time instead of money to exchange knowledge and skills. At the heart of the SkillSwap solution is the custom-built, artificial intelligence-driven algorithm called the SkillSwap Bidirectional Skill Swap Engine. The engine combines two types of data (self-reported preferences and verifiable historic data) to create a compatibility score with a maximum possible value of 100. To help clients establish bidirectional compatibility and commitment, a Mutual Swap Multiplier has been included in the scoring model. The Mutual Swap Multiplier is a factor of 1.0× for perfect bi-directional compatible matches, and 0.6× for one-sided relationships. The SkillSwap Bidirectional Skill Swap Engine leverages multiple advanced technologies to create the modern solution that SkillSwap offers. These technologies include React.js and Spring Boot for a scalable full-stack architecture, WebRTC for lag-free real-time collaboration, AI API (Groq API AI) for intelligent resume parsing and dynamic test generation, JWT based authentication for robust security, and Docker containerization for production ready deployment. There are ten functional modules in SkillSwap: Authentication, User Profiles, Resume Parsing, Assessment Test System, Skill Matching, Feedback, Teaching Room, Core Engine, Notifications, Real-Time Messaging.

CHAPTER 12

FUTURE SCOPE

The SkillSwap platform has a rich roadmap for future development. The following enhancements are planned for subsequent stages:

Advanced Machine Learning Integration

- **Graph Neural Networks (GNN):** Model the entire SkillSwap user base as a knowledge graph where nodes are users and edges are past skill swaps. GNNs can identify non-obvious, high-value match recommendations by detecting patterns across the social graph.
- **Natural Language Processing (NLP):** Analyse session chat transcripts, feedback text, and skill descriptions using NLP to extract richer insights about teaching quality, knowledge gaps, and popular skill combinations.
- **Reinforcement Learning for Matching:** Train an RL agent to optimize match recommendations based on long-term session success rates rather than static compatibility scores, continuously improving recommendation quality.

Mobile Application

Cross-Platform Mobile App: Develop a React Native or Flutter mobile application for iOS and Android, providing full SkillSwap functionality with push notifications, mobile-optimized whiteboard gestures, and offline profile viewing.

Progressive Web App (PWA): As an interim step, convert the existing React.js frontend to a PWA for installability and limited offline functionality.

Gamification & Engagement

Achievement Badges: Award digital badges for milestones such as 'First Session Completed', '10 Skills Taught', 'Top-Rated Tutor', and 'Skill Diversity Champion'.

Skill Progression Pathways: Define structured learning paths (e.g., 'Web Development Roadmap') and track user progress through peer-taught milestones.

Leaderboards: Department-level and institution-level leaderboards for most active tutors and learners, fostering healthy competition and community recognition.

Institutional Integration

LMS Integration: Provide plugin connectors for popular Learning Management Systems (Moodle, Blackboard, Canvas) University Deployment Programme: Partner with universities across India (starting with SPPU-affiliated institutions) to deploy institution-specific instances with dedicated skill catalogues aligned to curriculum.

Group Sessions & Workshops

Extend the teaching room to support multi-participant sessions (up to 20 users) for workshops, hackathon prep, or group study circles.

Allow users to create and schedule open-enrollment workshops on any topic, visible to all platform users.

Regional Language Support

Add multilingual support for the platform UI, assessment tests, and notification messages to make SkillSwap accessible to students across India's diverse linguistic landscape (Hindi, Marathi, Tamil, Bengali, Kannada, etc).

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