AI-POWERED PERSONALIZED LEARNING PATH GENERATOR

[1]N.Indhumathi, [2]K. Kalaiyarasan, [3]M. Sanjay, [4]R. Thusenthira Kumar, [5]S. Vinoth
[1]Assistant Professor, [2345]Student
[12345]Salem College Of Engineering and Technology, Salem- Attur Main Road, M.Permapalayam, Selliamman Nagar, Salem
[1]indhumnr2693@gmail.com, [2]kalaiyarasan17cse@gmail.com, [3]sanjaymahendran832@gmail.com, [4]thusenthirak@gmail.com

***Abstract*—In today's educational environment, maintaining accurate and efficient attendance tracking is crucial for ensuring discipline and monitoring student participation. Traditionally, attendance has been recorded manually through roll calls or signature sheets, which are prone to errors, proxy attendance, and administrative delays. Existing automated methods have attempted to address these issues using RFID cards, biometric fingerprint systems, or simple face recognition; however, these solutions often fall short as RFID cards can be easily misused and standalone biometric systems cannot fully eliminate impersonation risks. In the proposed system, a Smart Attendance System using Embedded Technology is developed, integrating face recognition, fingerprint verification, and SMS alert mechanisms into a single secure platform. The system utilizes an ESP32 as the primary controller interfaced with a high-definition camera for face recognition, a fingerprint sensor module for biometric verification, and a Python script is used to send SMS alerts to parents once attendance is successfully marked.**

The working process begins when a student approaches the system; the camera captures and verifies the student's face against the database, after which the student scans their fingerprint for second-level authentication. Upon successful verification of both biometrics, the attendance is logged in the database and an SMS notification is sent to the parent, significantly reducing the possibility of proxy attendance and strengthening security. Compared to existing methods, the dual authentication approach ensures more robust identity confirmation, while real-time SMS alerts keep parents informed and engaged. In conclusion, the proposed embedded smart attendance system offers a secure, reliable, and automated solution that not only streamlines attendance management but also enhances transparency and trust between educational institutions, students, and parents.

I. Introduction

A Personalized Learning Path Generator is an innovative solution designed to automate the process of academic and career planning in educational institutions, corporate training centres, or any setting where tailored skill acquisition is essential. Traditional methods of learning path development, such as manual counselling or generic course syllabi, are time-consuming, often outdated, and vulnerable to gaps in prerequisite knowledge, including misalignment with current industry demands. To address these issues, a smart learning path generator leverages advanced technologies like Artificial Intelligence (AI), Natural Language Processing (NLP), and interactive Chatbots to ensure personalized, accurate, and real-time educational guidance.

The core of the system utilizes sophisticated AI modules such as skill detection and market-gap analysis to verify the identity of the learner's current competencies and their professional aspirations. The chatbot-driven identification system uses natural language understanding (NLU) to capture and analyse user inputs, ensuring that the system understands the specific goals and nuances of the individual's learning

journey. Similarly, progress tracking provides an additional layer of engagement by verifying the user's advancement through the roadmap based on task completion and assessment. When the system confirms a user's mastery of a module, it marks that specific milestone as achieved and updates the roadmap in a digital format.

To enhance the functional utility, the system also includes real-time notifications, which automatically alert the user about upcoming modules, new resources, or changes in skill requirement trends. This helps to keep the learner informed in real-time, ensuring transparency and trust in the system's recommendations. Additionally, the system can be integrated with cloud-based learning management systems (LMS) for centralized data storage, enabling easy access and analysis of learning records. In summary, the Personalized Learning Path Generator not only streamlines the educational planning process but also strengthens learner outcomes by using AI-driven authentication of skills. It reduces information overload, prevents "learning fatigue," and provides instant feedback, making it an efficient, reliable, and scalable solution for modern-day professional upskilling needs.

II. LITERATURE REVIEW

A variety of research efforts have focused on developing smart learning systems that enhance personalization and automated guidance. In 2018, S. A. Patil and P. S. Patil in their paper titled "Smart Academic Pathfinding Using Recommendation Systems" proposed a system based on course discovery using collaborative filtering on cloud platforms. Their system emphasized reducing student confusion and minimizing manual counsellor intervention, laying the groundwork for digital solutions that require minimal human supervision. Similarly, in 2019, S. K. Shinde et al. presented the work "Skill-Based Resource Mapping for Engineers" where they highlighted the reliability of specialized metadata indexing for medium to large scale educational organizations. Their system utilized a ranking algorithm to verify the relevance of learning materials, showcasing automated mapping as a more precise method over static textbook-based curricula.In 2020, N. V. Arunkumar et al. published "Hybrid AI for Personalized Learning" which combined NLP and Knowledge Graphs to ensure multi-factor verification of learning dependencies, thereby reducing the possibility of skipped prerequisites. The study introduced a layered methodology where a student’s prior skills had to be validated first, followed by a gap assessment against job roles, proving that multi-modal systems considerably improve system accuracy. In the same year, A. Kumar and M. Singh authored "IoT and AI for Real-time Skill Tracking", proposing a system where learning progress was immediately communicated to mentors via automated dashboards. This feedback loop was found to improve student engagement and mastery levels significantly.

Further, in 2021, P. Yadav and S. Gupta published "Chatbot-Based Support for Personalized Education" which designed a prototype using conversational agents for intent recognition and SQL databases for local storage. Their system addressed the user-experience gaps in traditional LMS by allowing students to query the system for guidance even during non-academic hours. In a more recent study in 2022, M. R. Shaikh and H. M. Deshmukh in "Advanced Adaptive Roadmap Generation with Deep Learning" combined neural-network-based recommendation models with traditional rule-based logic to enhance the security and reliability of learning paths. Their system integrated cloud synchronization features and emphasized scalability for large-scale corporate training environments. Overall, the literature consistently suggests that AI and Chatbot-based multi-modal systems, when combined with real-time feedback mechanisms, provide a robust, scalable, and reliable alternative to traditional educational planning methods.

III. METHODOLOGY

The Personalized Learning Path Generator integrates Natural Language Processing (NLP), skill-gap analysis, and interactive chatbot technologies within an intelligent software framework to deliver accurate and personalized career roadmaps. The system begins by initializing its core modules, including the Natural Language Understanding (NLU) engine, the recommendation database, and the user profile management system. When a learner interacts with the chatbot, the system collects essential information such as

educational background, existing technical skills, career objectives, and learning preferences. The textual inputs provided by the user are processed using NLP techniques to extract key skill entities and intent patterns, which are then mapped against predefined career role templates stored in the database. Once the target role is identified, the system performs a skill-gap analysis by comparing the learner's current skill set with industry-aligned role requirements.

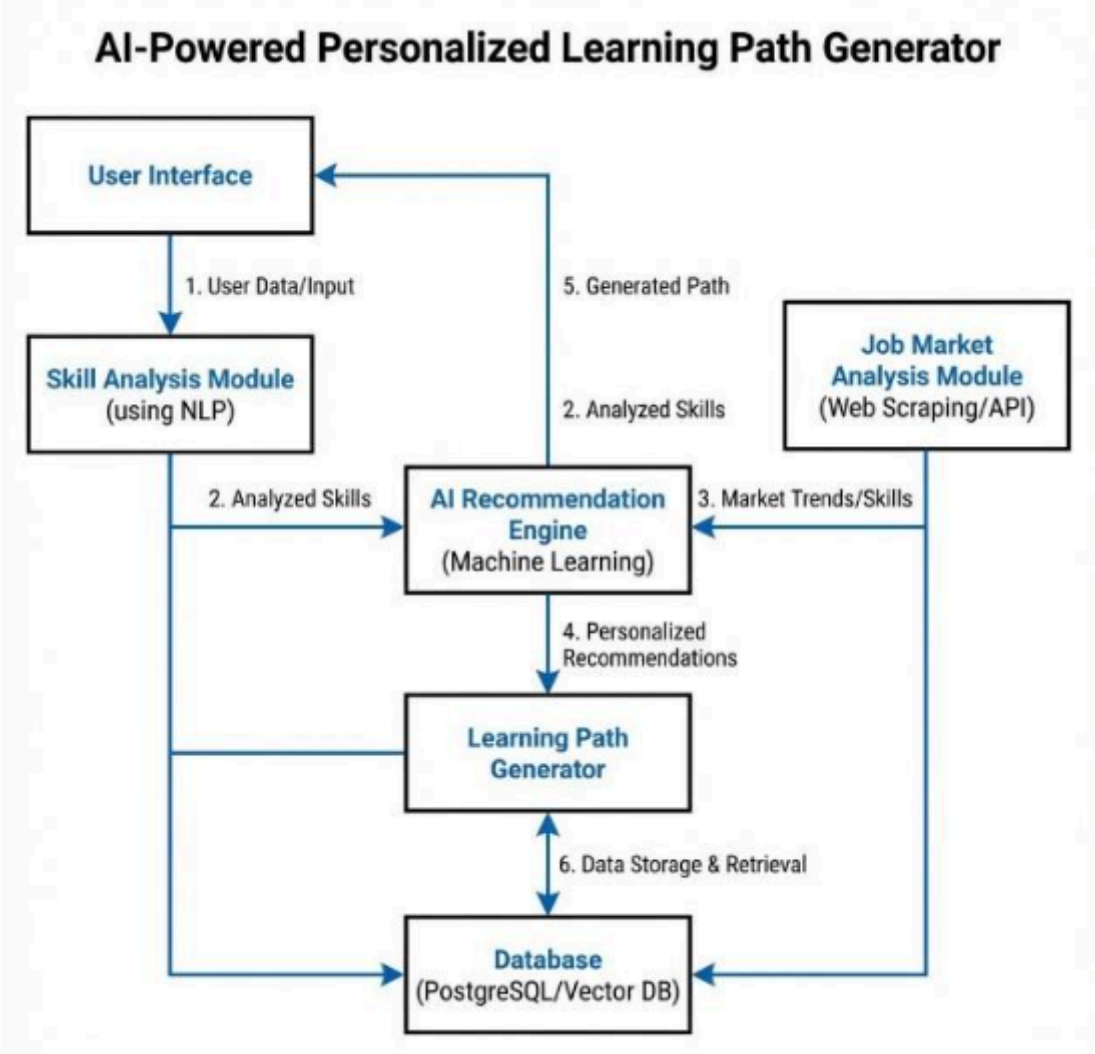

Fig 3.1 System Architecture of AI-Powered Personalized Learning Path Generator.

Missing or weak competencies are identified and prioritized using similarity scoring and dependency-based sequencing to ensure a logical learning order. Based on the identified gaps, the recommendation engine generates a structured and personalized learning roadmap consisting of relevant courses, learning resources, and practice modules. The system continuously monitors learner progress and adapts the roadmap dynamically based on performance feedback and user interaction. Through real-time chatbot guidance and adaptive recommendations, the proposed methodology ensures an efficient, scalable, and automated solution for personalized learning path generation while minimizing redundant learning and improving learner engagement.

1. **Learner Data Collection**

Learner data collection is a crucial initial step that ensures the system functions accurately and securely. During the orientation or onboarding phase, each student's essential information must be gathered and securely stored. This includes basic personal details like Name, current education level, target job role, and preferred learning style (e.g., Video, Text, or Hands-on labs). Alongside this, competency data is

collected — specifically, textual descriptions of prior work and project experiences. For intent recognition, multiple conversational prompts are presented in various contexts to create a robust dataset that improves the chatbot's understanding accuracy during real-world interactions. The inputs are processed and converted into feature vectors using deep learning models (e.g., using Word2Vec or Transformer encodings). For skill validation, the student may be required to answer diagnostic questions to verify several proficiency levels, ensuring a high-quality profile that can accommodate variations in self-assessment. The collected "Skill Vectors" are then linked to the student's ID in a secure database.

2. NLP Intent Recognition and Parsing

Intent recognition is a key feature of the system, leveraging computer vision (for document parsing) and NLP algorithms to automate profile building. The process begins with capturing a student's career aspirations through a conversational interface. The system uses an intent detection algorithm to locate the core objective within the text. Once detected, it is processed to extract unique technical features like "Python," "Deep Learning," or "Project Management," which are characteristic to the target role. These features are then converted into a "Market Target Template." The first time a student uses the system, their profile is enriched by capturing multiple inputs from different perspectives to create a more robust template. These vectors are stored in a local or cloud database, ensuring they are easily retrievable for future roadmap updates. When a student enters a new query, the system continuously analyses the context and compares it with the stored templates.

3. Skill-Gap Analysis Logic

Skill-gap analysis is a highly reliable process that identifies individuals' missing competencies based on the unique patterns of their current skill vector vs the target market vector. In the smart learning system, this method is used to ensure that the modules recommended are indeed the ones required, thereby preventing redundant or irrelevant learning entries. The system begins by mapping the user's profile against the job market requirements.

During this mapping, the system captures the "distances" between skill points and processes them to extract distinguishing "Gaps." If a match is found for a skill, it is skipped; if not, the gap is recorded with a priority level. This gap-analysis logic is highly reliable due to the uniqueness of every role's requirement, making it an effective solution for dynamic professional environments. For added efficacy, this analysis is combined with another factor such as pedagogical sequencing (Knowledge Graphs), ensuring a logically sound learning path.

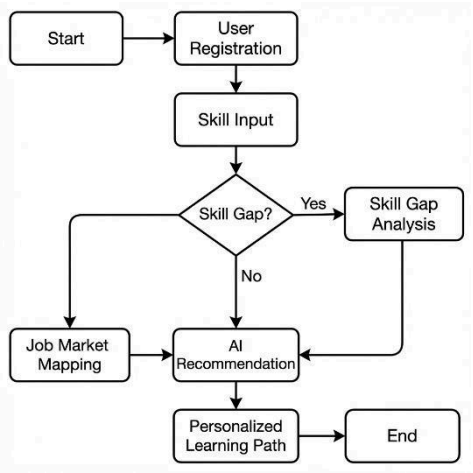

Fig 3.3 Sample Personalized Learning Roadmap

4. Multi-Phase Roadmap Generation

In a smart learning system designed for personalized guidance, each student goes through a quick yet thorough generation process that leverages multiple AI modules to ensure accurate roadmap marking within a limited duration. The system is optimized to complete the entire generation process in under a duration of minutes per user. Here's how it works:

1. **Initial Goal Detection**:

As soon as the student starts the chatbot, it instantly captures their technical aspirations using high-speed sentiment and intent algorithms. Within seconds, the system compares the intent with target role templates in the database.

2. **Secondary Gap Verification**:

Once the goal is confirmed, the student is asked to provide details on their project experience. The NLP module processes and matches the skills in under 2 seconds by comparing it against the saved market templates.

3. **Roadmap Logging & Alerts**:

After successful gap verification, the system marks the learning path and immediately triggers the update script to display the roadmap. Simultaneously, the system sends a notification to the user, assuring them of their structured journey. The generated roadmap is stored with a timestamp in the user profile for future reference and progress tracking. Additionally, the system continuously monitors learner interactions and dynamically updates recommendations to accommodate progress, feedback, or changes in career objectives.

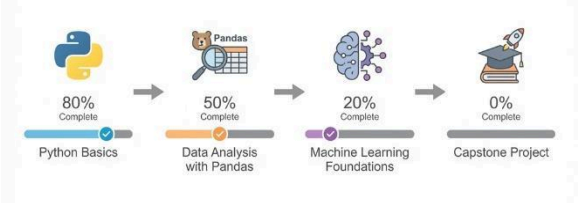

Fig 3.2 Flowchart of AI-Based Learning Path Generation

IV. RESULT

The Personalized Learning Path Generator was implemented by integrating NLP intent recognition, skill-gap analysis, and chatbot-driven alerting functionalities into a single cloud-native platform. The architecture consisted of a Python (Fast API) backend as the core controller, interfacing with a Vector Database for profile storage, a Knowledge Graph for curriculum logic, and a React-based conversational UI. During system operation, when a student approached the device (the web interface), the chatbot automatically activated and captured the live dialogue, which was processed using advanced NLP algorithms. If the intent matched an existing career path with a high confidence score, the system prompted the student to describe their technical background. The parser read the description and compared it to target skills.

Upon successful verification of both the intent and the gaps, the system recorded the student's personalized roadmap with a timestamp into a local database. Simultaneously, a welcome notification was sent to the user, confirming the generated path. The system handled multiple users efficiently, with average detection and verification times within 1–2 minutes, providing quick and seamless roadmap marking. In cases of mismatch or goal ambiguity, the system triggered a clarification prompt, ensuring high accuracy. The implementation demonstrated excellent reliability even under varied user input styles and showed robust performance across different professional backgrounds. Overall, the Smart Learning Path Generator provided a secure, fast, and automated solution to replace traditional counselling methods, enhancing transparency, minimizing wasted learning time, and improving real-time progress tracking.

V. CONCLUSION

The Personalized Learning Path Generator using an AI-driven platform with NLP detection, skill mapping, and chatbot alerts successfully addresses the common challenges of traditional educational methods, such as information overload, manual planning errors, and delayed curriculum feedback. By integrating conversational and analytical authentication, the system ensures a two-layer verification process, significantly improving the accuracy and relevance of learning recommendations. The use of real-time notifications keeps the learner informed about their status, promoting motivation and engagement. This system not only reduces the mental workload of career planning but also automates the educational process efficiently, saving time and resources for both individuals and institutions. Moreover, the design demonstrates how AI and chatbot technologies can offer scalable, reliable, and user-friendly solutions for modern digital environments. In conclusion, the project proves that conversational AI and machine learning can revolutionize conventional learning paths, leading to a smarter and more adaptive educational infrastructure. Future enhancements could include mobile app integration and advanced fraud detection for certification validation.

Additionally, the system supports continuous learning by dynamically updating roadmaps based on user progress and evolving industry requirements. Its modular architecture enables seamless integration with existing learning management systems, ensuring long-term adaptability, enhanced accessibility, and broader applicability across academic, corporate, and professional training environments.

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