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Personalized Learning Analytics Using AI

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Abstract

The increasing demand for personalized learning experiences in education has led to the development of a Personalized Learning Analytics system powered by AI and enhanced with Randomized Algorithm Design (RAD). The system forecasts results, evaluates student performance, and offers personalized learning trajectories. RAD maximizes prediction accuracy through random selection of past data, ensuring for the purpose of offering objective analysis. Students can track progress and receive personalized feedback, and instructors can track class performance through individual interfaces. Career guidance is offered through an AI chatbot, and cloud scalability guarantees seamless operation.

Keywords: *AI Artificial Intelligence; NLP Natural Language Processing; RAD Randomized Algorithm Design.*

1. Introduction

In the evolving landscape of education, personalized learning has emerged as a powerful approach to enhancing student performance and engagement. With the increasing need to cater to the unique learning needs of each student, our project, Personalized Learning Analytics Using AI, seeks to provide a dynamic and individualized learning experience that adapts to students' academic performance. By analyzing students' previous academic records and their performance in online assessments, the system categorizes them into three groups— below average, average, and above average—based on specific thresholds. This categorization is essential in delivering assessments tailored to the student's current level, ensuring that each learner is appropriately challenged and has opportunities to improve. To further enhance the accuracy and fairness of the categorization, the project employs a Randomized Algorithm Design (RAD) for the selection of academic data during the analysis phase. By introducing randomness in selecting historical performance data, the system avoids bias that could arise from relying on a fixed dataset. This randomized approach ensures a more diverse and representative data sample, which leads to better performance predictions and personalized recommendations for each student. The project goes beyond traditional assessment systems by not only tracking academic performance but also offering actionable insights into areas where students need improvement. For instance, students identified as needing extra support in certain subjects will receive recommendations on which topics to focus on. Additionally, with the help of a RAD-enhanced data selection, the system provides more accurate psychological advice and career guidance, making it a holistic tool for student development. These recommendations are designed to help students enhance both their academic performance and overall well-being. Teachers play a crucial role in this process, and the system is designed to empower them with the ability to monitor student progress

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effectively. Through the platform, teachers can track assessment outcomes, provide feedback, and understand student needs, all within a single interface. This enables educators to quickly identify struggling students, assess class performance, and offer targeted support where necessary, significantly simplifying the evaluation process. In essence, Personalized Learning Analytics Using AI—aided by RAD— offers a comprehensive solution that fosters an engaging learning environment. It helps students improve in areas they need the most, while also allowing teachers to better manage and support their learners. By leveraging RAD, AI, and data-driven insights, this project seeks to create a more efficient, adaptive, and student-centered educational experience that can transform how academic success is achieved.

2. Related Works

Various approaches have been explored to utilize artificial intelligence and learning analytics to enhance student performance and engagement. The following sections discuss key studies and methodologies relevant to our project on

2.1.Personalized Learning Analytics.

The exploration of AI in higher education provides personalized feedback and adaptive assessments by leveraging AI algorithms to identify individual strengths and areas for improvement, thus enhancing learning outcomes [1]. While the focus is on formative assessments and tailored feedback, our project similarly analyzes students' academic performance through online assessments, categorizing them into three performance levels—below average, average, and above average—and providing assessments accordingly. Additionally, our project incorporates psychological and career guidance alongside academic feedback, offering a more comprehensive approach to student development. A multimodal data integration approach coupled with deep reinforcement learning has been proposed to enhance personalized education in the digital era, focusing on providing tailored learning experiences and privacy-preserving personalized feedback [3]. While this paper explores the use of multimodal data and advanced reinforcement learning techniques, our project similarly aims to analyze student performance through personalized assessments, categorizing them into performance tiers. Additionally, our approach integrates psychological and career guidance, offering a holistic view of student development, and complementing the educational feedback system. A random forest-based model to predict students' course grades using seven input predictors is discussed in this study [5]. The model analyzes data from 650 undergraduate students and highlights that grade point average and high school score are the most significant predictors of academic performance, while factors like course category and attendance percentage are also influential. The methodology helps in identifying students who may face challenges, allowing institutions to take corrective measures to improve student retention and completion rates. Similarly, in our project, student performance and academic data are leveraged to predict course outcomes and provide personalized feedback. Both approaches focus on predicting student success, but while this study uses random forest for individual course grades, our project employs AI models to analyze long-term academic performance and provide tailored assessments and career guidance. This study conducts an extensive survey on the evaluation of emerging e-learning systems using machine learning techniques such as supervised, semi-supervised, and reinforced learning methods [12]. The research focuses on analyzing e-learning models to optimize their performance by identifying significant features, including individual, course, context, and technology-relevant aspects [12]. It highlights how Support Vector Machines (SVM) and deep learning algorithms have been effective in tuning e- learning models, with a particular emphasis on handling big data [12]. In comparison, our project also uses machine learning models to analyze educational data, but it specifically focuses on personalized learning analytics and tailored feedback using Random Forest and Linear Regression. While both approaches share a common goal of improving learning outcomes, this study is centered on feature optimization in e-learning systems [12], whereas our project provides personalized assessments, career guidance, and

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academic predictions based on individual student performance data.Various studies have explored the role of learning analytics and adaptive feedback in improving student performance and engagement. A study proposed an adaptive feedback system that tailors feedback based on students' collaborative behaviors and gamification preferences to enhance personalized interactions [15]. While this system addresses the lack of personalization in student interactions, especially among students with different social and collaborative tendencies, it focuses primarily on providing feedback based on behavioral patterns. In comparison, our project takes a more holistic approach by integrating performance analysis across multiple academic metrics, such as past grades and assessment results, and provides tailored assessments and psychological feedback based on students' academic performance and progress. Similarly, another study examined how learning analytics and educational data mining can be applied to personalized learning environments to predict student engagement and long-term outcomes, such as college attendance and choice of major [16]. This paper highlights how analytics can be used to determine patterns of disengagement and optimize resource utilization, aligning with our project's goal of providing personalized career and academic advice based on the data analysis of students' performance. However, while the study [16] focuses on large-scale predictions across extended timelines, our project concentrates on more immediate, actionable insights through assessments and personalized learning pathways designed to cater to individual student progress throughout their academic journey. Our project distinguishes itself from these works by emphasizing both short-term academic predictions, such as CGPA, and personalized career guidance, combining aspects of real-time academic feedback, tailored assessments, and psychological support through AI-driven analytics. Moreover, the integration of a chatbot for interactive learning and advice further differentiates our approach from these existing models [15,] [16].

3. Proposed Methodology

The proposed system architecture utilizes Artificial Intelligence (AI), machine learning models, Randomized Algorithm Design (RAD), and data analytics to create a personalized learning platform for engineering students. This platform offers adaptive learning experiences by analyzing individual student performance and tailoring content to meet specific learning needs. Key features include predicting Cumulative Grade Point Averages (CGPA), real-time performance tracking, and personalized career guidance. Integrating RAD enhances the data sampling process by ensuring a random and unbiased selection of historical academic data, improving the accuracy of predictions and recommendations. The system is divided into distinct modules for students and teachers. The student module facilitates an interactive learning journey with tailored assessments and feedback, while the teacher module provides detailed performance data for informed interventions and lesson planning. Together, these modules streamline the educational process, promoting effective learning strategies and improving academic outcomes through adaptive, data-driven insights. (Figure 1)

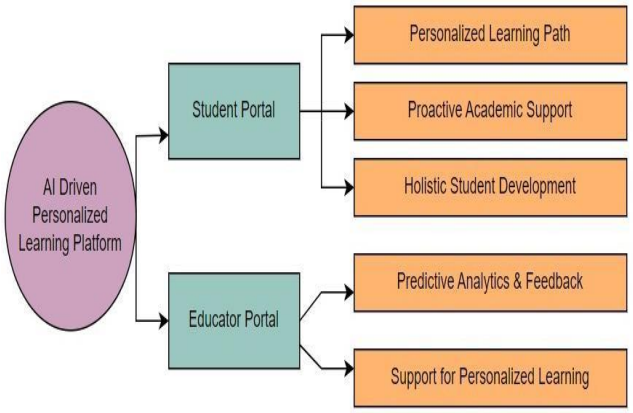

Figure 1 Proposed Solution

3.1.Student Module

The Student Module facilitates student interactions with the personalized learning system. It provides functionalities such as secure login, adaptive assessments, performance tracking, CGPA predictions, and a chatbot for career and psychological advice. This module enhances the student's learning experience by tailoring content and assessments according to their academic performance and needs.

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3.1.1. Login and Profile Setup

The system begins by collecting student details during the registration process. The data is securely stored for further analysis and includes:

- **Basic Information:** Name, department, and email.
- **Educational Background:** Marks from previous semesters (up to 8), parents' educational background, and other demographic data.
- **Password Authentication:** Secure login with encrypted password protection is ensured through AES-256 encryption.

3.1.2. Adaptive Assessments

Assessments are dynamically assigned based on a student's prior performance. The difficulty level is categorized as Easy, Medium, or Difficult.

- **Algorithm Used:** A K-Means Clustering algorithm will categorize students into clusters based on previous academic performance. The number of clusters (K) will be optimized using the Elbow Method.
- **Performance Monitoring:** Using Reinforcement Learning (Q- Learning), the system tracks performance and decides whether a student progresses to the next difficulty level or regresses to a simpler level. Based on the student's assessment results, learning paths will be adjusted in real-time.

3.1.3. CGPA Prediction

The AI model will predict the student's CGPA based on their performance in assessments, previous semester marks, and engagement metrics.

- **Algorithm Used:** The system uses Linear Regression to predict the future CGPA based on: Performance in adaptive assessments, Participation and attendance in classes, Previous academic records (semester-wise).
- **Performance Metrics:** Mean Absolute Error (MAE) and Root Mean Square Error (RMSE) will be employed to evaluate the accuracy of CGPA predictions.

3.1.4. Personalized Chatbot

A Natural Language Processing (NLP)-based chatbot will assist students by providing personalized advice and support.

- **Career Guidance:** The chatbot uses historical performance data to suggest career options suitable for the student's skill set.
- **Psychological Advice:** Based on sentiment analysis of student interactions, the chatbot will offer psychological support and advice, ensuring the student's mental well- being.
- **Algorithm Used:** Pre-trained models like BERT or GPT will be employed for sentiment analysis and contextual guidance. (Figure 2)

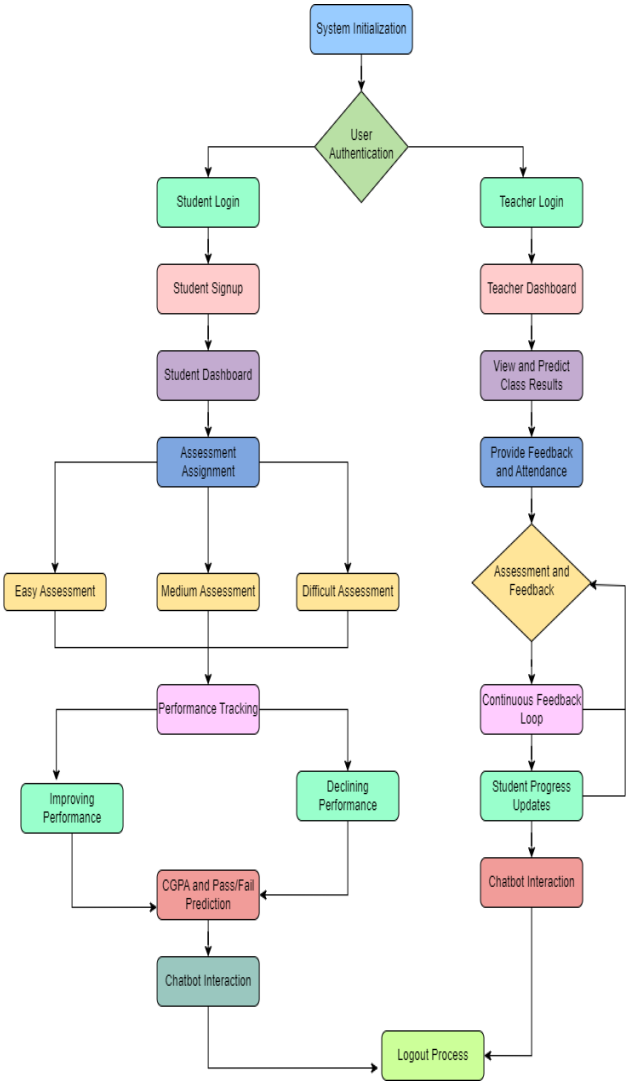

Figure 2 Architecture Diagram

3.2.Teacher Module

The Teacher Module enables educators to monitor student performance, provide feedback, and predict class-wide outcomes such as overall CGPA. Teachers

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have access to detailed analytics on individual students as well as class-level data.

3.2.1. Teacher Login and Dashboard

Teachers log in to a secure platform that grants access to student data and allows them to provide feedback. Role-Based Access Control ensures that teachers can only access data relevant to their classes while protecting student privacy.

3.2.2. Class-Wide CGPA Prediction

Teachers can use the system to predict the overall class CGPA based on individual student performance data.

- **Algorithm Used:** A Multiple Regression Model will analyze the entire class's academic history and assessment results to forecast the collective CGPA. Incorporating RAD helps in random sampling of students' historical data, which reduces bias in the predictions.
- **Visualization:** Data visualization tools like D3.js or Chart.js will provide an intuitive dashboard for teachers to track student progress and analyze prediction outcomes.

3.2.3. Student Feedback and Performance Review

Teachers will provide qualitative feedback based on student attendance, participation, and engagement.

- **Attendance Analysis:** Automated attendance tracking based on assessment participation will help teachers monitor class involvement.
- **Performance Feedback:** The system will allow teachers to input personalized comments on each student's progress and suggest improvements.

3.3.System Module

The System Module serves as the core component responsible for managing data flow, executing AI models, and ensuring secure data storage.

3.3.1. Database Management

- **Database Storage:** Student and teacher data, including academic records, assessment results, and performance analytics, will be securely stored in a MongoDB database.
- **Data Encryption:** Sensitive data, such as login credentials and personal information, will be encrypted using AES-256 encryption to prevent unauthorized access.

3.3.2. Performance Tracking and Analytics

Performance data will be continuously collected and analyzed to track student progress. This analysis will be used to adjust assessment difficulty and improve prediction accuracy.

- **Trend Analysis:** The system will use Time-Series Analysis (ARIMA models) to detect patterns in student performance over time.
- **Learning Curves:** Learning Curves will be generated for each student, helping to visualize the rate of improvement or regression across different assessment levels.

3.3.3. Model Validation and Optimization

- **Cross-Validation:** The machine learning models will undergo K-Fold Cross Validation to ensure robustness and prevent overfitting.
- **Hyperparameter Tuning:** Models like Random Forest and Decision Trees will be optimized using Grid Search to find the most effective parameters for accurate predictions.

3.3.4. Evaluation Metrics

Confusion Matrix for pass/fail prediction.
Precision, Recall, and F1-Score for classification accuracy.

3.4.Security Module

Security and privacy are critical aspects of the proposed system. The platform will implement several measures to protect user data and ensure secure communication between different components.

3.4.1. Secure Authentication

Two-factor Authentication (2FA) will be integrated to protect user accounts from unauthorized access.
Upon login, users will receive a one-time passcode (OTP) sent to their registered email or phone number.

3.4.2. Data Encryption and Privacy

- **Data Encryption:** All sensitive data (personal information, assessment records) will be encrypted using SSL/TLS protocols during transmission.
- **Privacy Compliance:** The system will adhere to global privacy standards like GDPR to protect student and teacher data.

3.4.3. Role-Based Access Control (RBAC)

To ensure data privacy, RBAC will be implemented,

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allowing different levels of access for students, teachers, and administrators. (Figure 3)

4. Implementation and Results

Figure 3 Login Page

Figure 3 depicts a secure access point for students and teachers with role-based authentication and optional two-factor security.

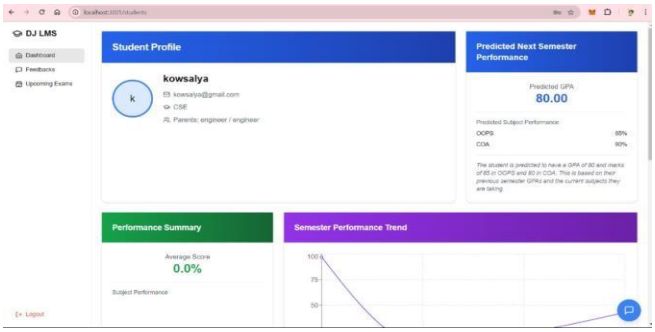

Figure 4 Student Dashboard

Figure 4 shows a personalized interface displaying performance insights, assessment results, and tailored recommendations.

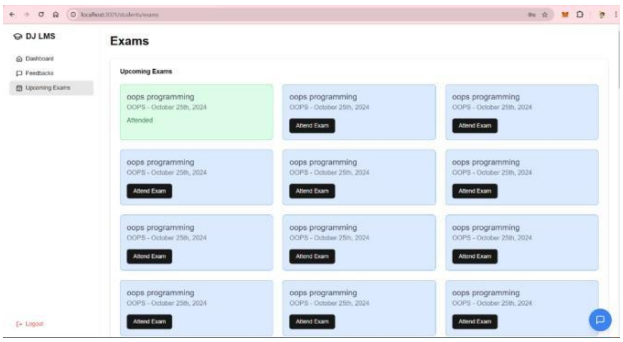

Figure 5 Student Assessment Page

Figure 5 facilitates adaptive assessments with real-time performance tracking and personalized difficulty levels.

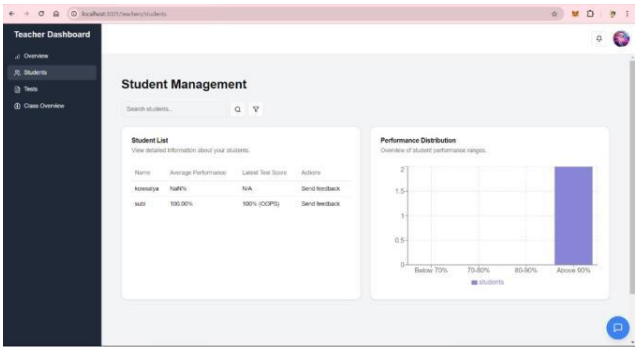

Figure 6 Student Management-Teacher Dashboard

Figure 6 enables teachers to monitor student progress, provide feedback, and analyze class performance.

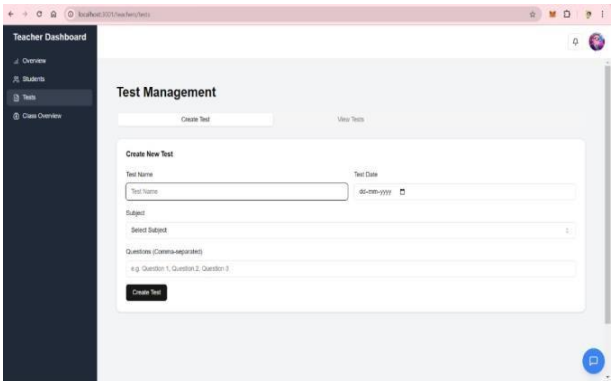

Figure 7 Test Assessment

Figure 7 conducts adaptive tests based on student performance, tracking progress and providing immediate feedback.

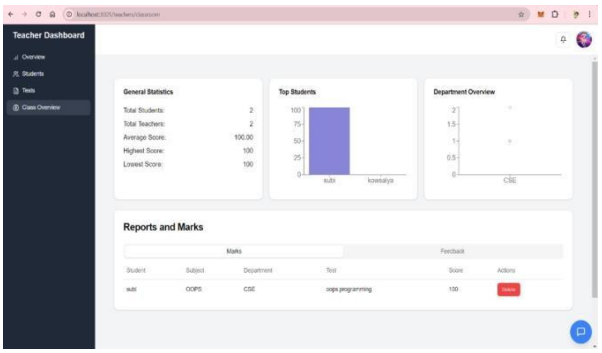

Figure 8 Class Overview – Teacher Dashboard

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Figure 8 provides teachers with insights into overall class performance, CGPA predictions, and attendance analytics.

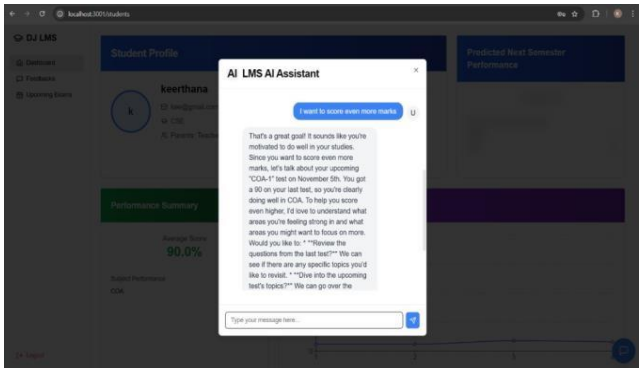

Figure 9 Student Chatbot

Figure 9 depicts an AI-powered assistant offering personalized career guidance, academic advice, and psychological support.

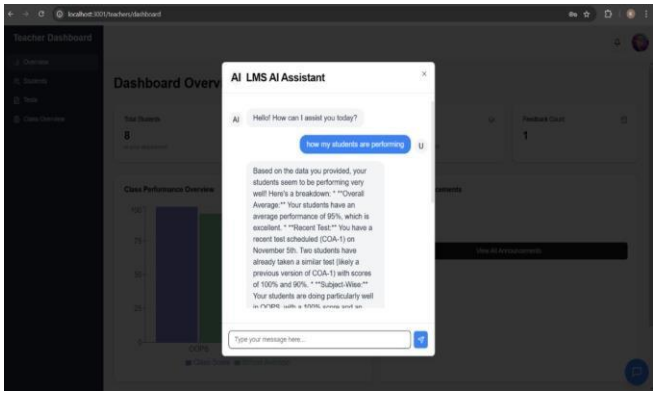

Figure 10 Teacher Chatbot

Figure 10 illustrates an AI-driven assistant that helps teachers provide personalized feedback, track student progress, and offer academic guidance.

Conclusion

In conclusion, the Personalized Learning Analytics system using AI provides an innovative approach to improving student performance through adaptive assessments, personalized feedback, and CGPA prediction. By utilizing data science and AI technologies, the system efficiently tracks individual student progress and adjusts learning paths based on performance, ensuring a customized educational experience. The inclusion of a chatbot for career guidance and psychological support further enhances student engagement, while the teacher's dashboard allows educators to monitor class performance and provide targeted interventions. This AI- driven platform bridges the gap between traditional learning methods and modern data-driven approaches, fostering an environment that supports both academic success and personal growth.

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