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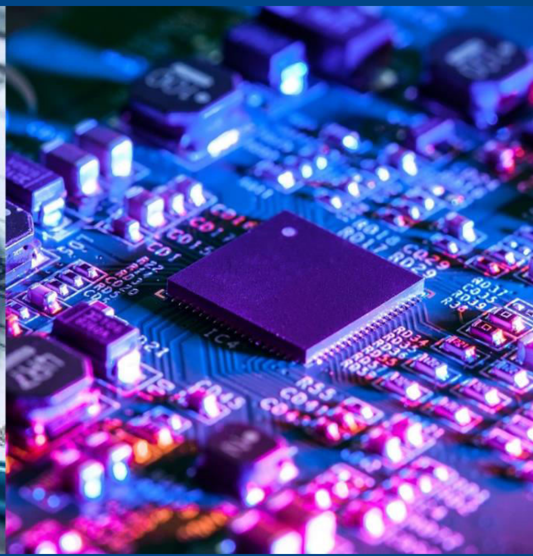

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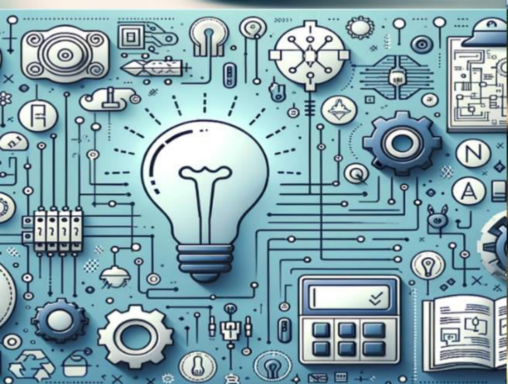

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Progresso: AI Enhanced Academic Growth Prediction & Personalized Recommendation System

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ABSTRACT: Progresso is an AI-powered academic growth prediction and personalized recommendation system designed to transform student learning outcomes through data-driven insights and adaptive learning strategies. Leveraging cutting-edge machine learning algorithms such Random Forest, and Neural Networks, Progresso analyses academic data to predict performance trends and deliver tailored recommendations for improvement. The system incorporates a robust data integration pipeline, beginning with CSV-based data collection and advanced preprocessing techniques to address missing values, normalize data, and encode variables for optimal model efficiency.

The architecture features a ReactJS-based interactive frontend, enabling real-time data updates, dynamic visualizations, and intuitive user portals for students and educators. These portals facilitate continuous performance monitoring, actionable feedback, and a holistic view of academic progress. A built-in feedback loop dynamically refines predictive models to ensure precision and relevance over time.

Progresso's implementation, achievable within six months and empowers students to overcome learning challenges, harness their strengths, and achieve their full potential. Simultaneously, it equips educators with comprehensive, real-time analytics to enhance classroom strategies and foster collaborative learning environments. By integrating advanced machine learning and real-time interactivity, Progresso represents a significant advancement in personalized education, setting a new standard for academic success.

KEYWORDS: Personalized recommendations, Preprocessing, Real-time data updates, Dynamic visualizations, Data-driven insights, Personalized learning strategies

I. INTRODUCTION

In today's dynamic educational landscape, the demand for personalized learning solutions has become paramount. Traditional teaching methodologies often fall short in addressing the diverse academic needs and behavioral patterns of individual students, leaving many learners underserved. This underscores the need for intelligent, data-driven systems capable of analyzing vast amounts of academic data to provide actionable insights for educators and tailored recommendations for students.

The proposed project, **Progresso**, introduces an AI-powered academic growth prediction and personalized recommendation system designed to revolutionize how educators and students engage with learning. By leveraging advanced machine learning algorithms—such as Linear Regression, Decision Trees, Random Forest, and Neural Networks—Progresso predicts student performance trends based on historical academic data, including exam results, attendance records, and demographic factors. This facilitates the identification of potential challenges and opportunities, paving the way for timely and impactful interventions.

Progresso features a seamless data integration pipeline that supports CSV-based input, advanced preprocessing to handle missing values, and optimized encoding for precise predictive modelling. A user-friendly, ReactJS-powered frontend complements the backend, offering real-time data updates, dynamic visualizations, and intuitive portals for both students and educators. These portals enable educators to track class performance trends, while providing students with actionable, personalized feedback—ultimately fostering a collaborative and adaptive learning environment

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II. LITERATURE REVIEW

Machine learning and AI-driven systems are revolutionizing education by addressing challenges that traditional methods and tools fail to overcome. While Learning Management Systems (LMS) and Student Information Systems (SIS) primarily function as repositories for academic data, they lack the predictive capabilities and personalized insights required for proactive educational strategies. Machine learning models, such as decision trees and support vector machines, have demonstrated the ability to predict student performance with high accuracy, enabling the early identification of at-risk learners. This proactive approach facilitates timely and targeted interventions, helping educators address potential issues before they escalate and significantly improving overall learning outcomes.[1] Beyond predictions, AI-powered systems provide enhanced personalization through adaptive content delivery and real-time feedback mechanisms. These capabilities ensure that each student's unique learning needs and challenges are addressed, resulting in improved engagement, academic performance, and retention rates. By tailoring educational experiences to individual learners, these systems create a more inclusive and effective learning environment.[2] Educational data mining (EDM) further amplifies the impact of AI in education by uncovering hidden patterns and trends within vast datasets. These insights not only aid in developing personalized strategies for student success but also enable institutions to refine their curricula, optimize teaching methods, and enhance resource allocation. By leveraging these predictive analytics and data-driven strategies, educational institutions can transition from reactive approaches to proactive, insight-driven decision-making.[3] Collectively, these advancements underscore the transformative potential of AI and machine learning in education. They empower educators with actionable insights, enable personalized learning paths for students, and provide institutions with the tools to enhance academic success and operational efficiency. By bridging the gap between raw data and meaningful insights, these technologies ensure a more adaptive, efficient, and impactful educational ecosystem.

III. SYSTEM ARCHITECTURE

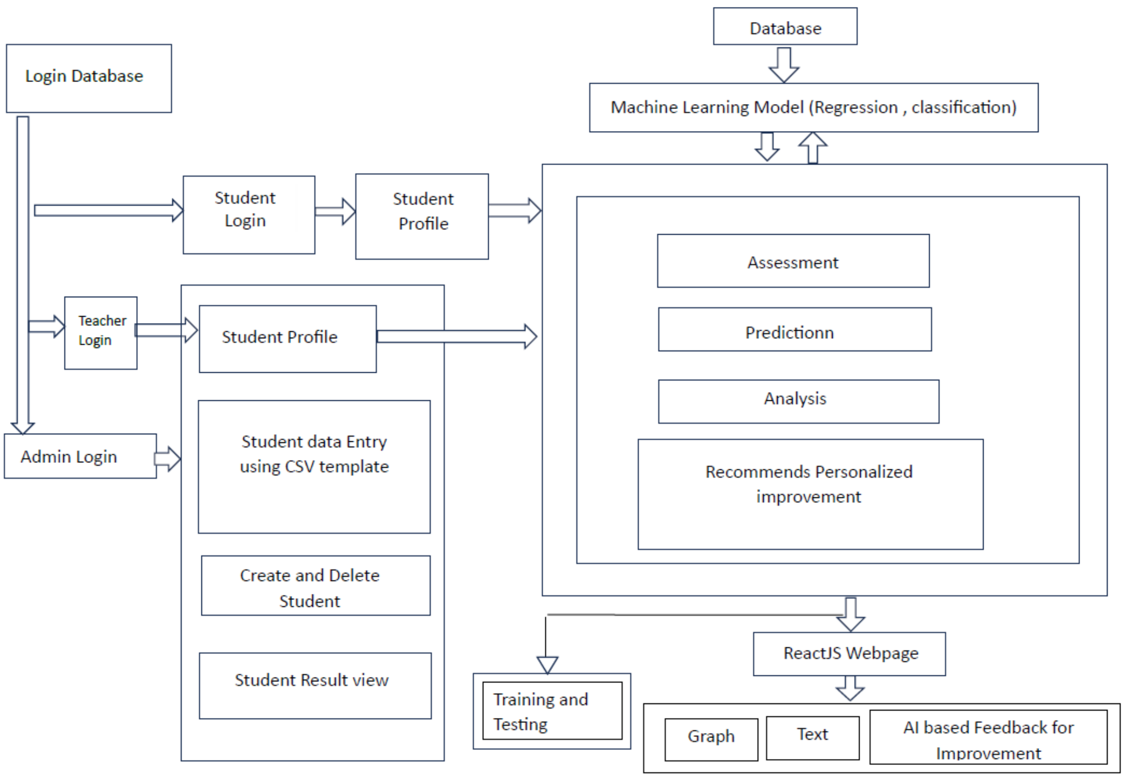

Fig. 3.1 system architecture

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The proposed system architecture integrates key components to create an intelligent academic growth platform. It features a centralized login database for secure, role-specific access, with teachers managing student data and students accessing personalized academic profiles. Teachers input performance metrics, which power a machine learning model for predictive insights, including performance assessments and future trends. Admins is Responsible for uploading student data using a CSV template, ensuring efficient data entry.AI-driven recommendations identify areas for improvement and offer personalized strategies. The ReactJS frontend presents dynamic dashboards, interactive charts, and automated reports for easy data interpretation. The system supports semester-wise and yearly progress tracking, with automated reports and AI feedback for continuous improvement. This design provides personalized guidance for students and actionable analytics for educators, fostering an adaptive educational environment.

IV. METHODOLOGY

The Progresso framework employs a structured and data-driven methodology to predict student performance and generate personalized recommendations. This approach integrates advanced machine learning models, data preprocessing techniques, and interactive visualizations to provide actionable insights for students and educators. The methodology consists of the following key steps:

1. Data Collection and Preprocessing

- **Data Collection:**
  - Gather academic data (e.g., test scores, attendance) and behavioral data (e.g., participation, extracurricular activities).
  - Store data in two CSV files:
    - Previous batch data: For training machine learning models.
    - Current batch: For making predictions on new data.
- **Data Preprocessing:**
  - Handle missing values by imputing with mean/median or removing incomplete records.
  - Normalize numerical features using Min-Max scaling or Z-score normalization.
  - Encode categorical variables using one-hot encoding or label encoding.
  - Split batch1.csv into training (80%) and testing (20%) datasets.

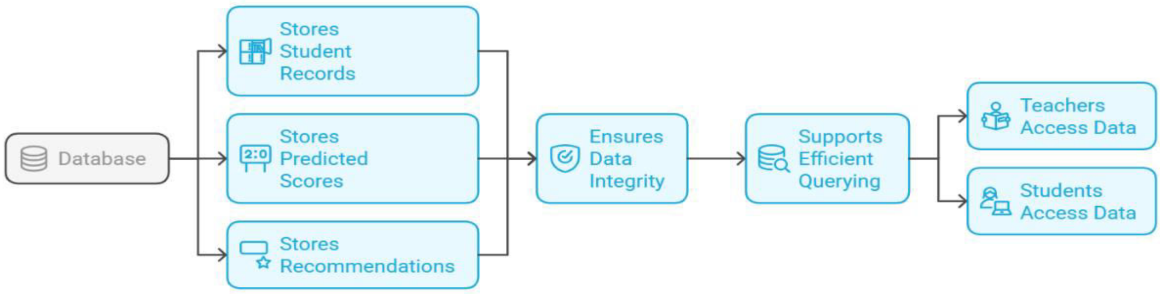

Fig.4.1 Data collection and preprocessing

2. Model Development

- **Model 1: Random Forest Regressor:**
  - Purpose: Predict grades for SEM_5 and SEM_6.
  - Implementation:
    1. Feature Selection: Use features like attendance, test scores, and behavioral data.
    2. Training: Train the model on the training dataset.
    3. Hyperparameter Tuning: Optimize hyperparameters (e.g., number of trees, max depth) using GridSearchCV or RandomizedSearchCV.
    4. Evaluation: Evaluate the model on the test dataset using Mean Absolute Error (MAE) and R^2 score.

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- Achieve MAE: 0.5 and R^2: 0.85.
  5. Prediction: Use the trained model to predict grades for new data in unseen_data.csv.
- **Output**: Predicted grades for SEM_5 and SEM_6.

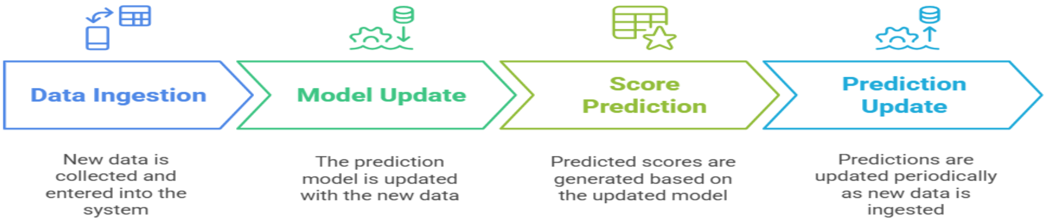

Fig.4.2 Performance Prediction model

- **Model 2: K-Nearest Neighbors (KNN):**
  - Purpose: Cluster students into Low, Medium, and High performance groups.
  - Implementation:
    1. Feature Selection: Use the same features as the Random Forest model.
    2. Training: Train the KNN clustering model on the training dataset.
    3. Hyperparameter Tuning: Optimize hyperparameters (e.g., number of neighbors, distance metric) using Grid Search CV.
    4. Clustering: Assign students to performance groups (Low, Medium, High) based on their academic and behavioral data.
    5. Evaluation: Validate clustering results using silhouette score or elbow method.
  - **Output**: Performance group (Low, Medium, High) for each student.

3. Personalized Recommendations

- **Integration with GPT-2:**
  - Use performance groups from KNN to generate personalized recommendations.
  - Examples:
    - Low Performance: Suggest study resources, time management tips, and counseling.
    - Medium Performance: Recommend advanced study materials and practice tests.
    - High Performance: Encourage participation in competitions and leadership roles.
- **Output**: Text-based recommendations tailored to each student.

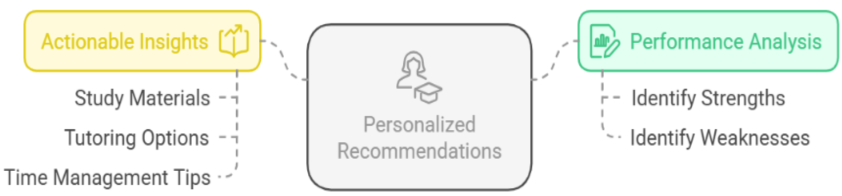

Fig.4.3 Recommendation System

4. Backend Development (Flask)

- **API Endpoints:**
  - /predict-grades: Accepts student data and returns predicted grades.
  - /get-recommendations: Accepts student data and returns personalized recommendations.
  - /upload-data: Allows admins to upload new data via CSV files.

- **Data Handling:**
    - Preprocess incoming data before passing it to the models.
    - Store predictions and recommendations in a temporary database or JSON files.
- **Model Integration:**
    - Load trained models (Random Forest and KNN) into the Flask backend.
    - Use the models to make predictions and generate recommendations.

5. Frontend Development (React.js)

- **Student Dashboard:**
    - Display predicted grades (SEM_5 and SEM_6).
    - Show performance charts (e.g., bar charts, line graphs).
    - Provide personalized recommendations.
- **Teacher Dashboard:**
    - View all students' performance data.
- **Admin Dashboard:**
    - Upload new data using a CSV template.
    - View system logs and model performance metrics.

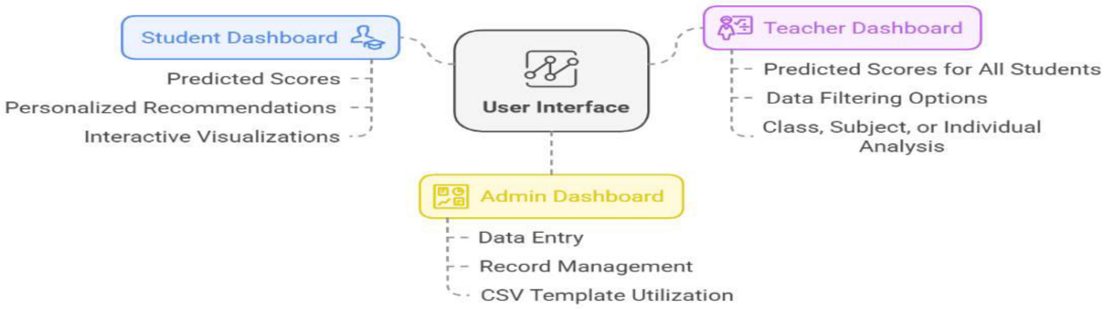

Fig.4.4 User interface

6. System Integration and Deployment

- **Frontend-Backend Communication**:

Use Axios in React.js to send HTTP requests to the Flask backend.

- **API Response Handling**:

Flask backend processes requests, invokes models, and sends responses in JSON format

- **Real-Time Updates**:

Use React state management (e.g., useState, useEffect) to dynamically update the UI based on API responses.

7. Testing and Maintenance

- **Testing**:
    - Test frontend components using Jest and React Testing Library.
    - Test backend APIs using Postman or pytest.
    - Validate model predictions and recommendations.
- **Maintenance**:
    - Periodically retrain models with new data.
    - Collect user feedback and address bugs.

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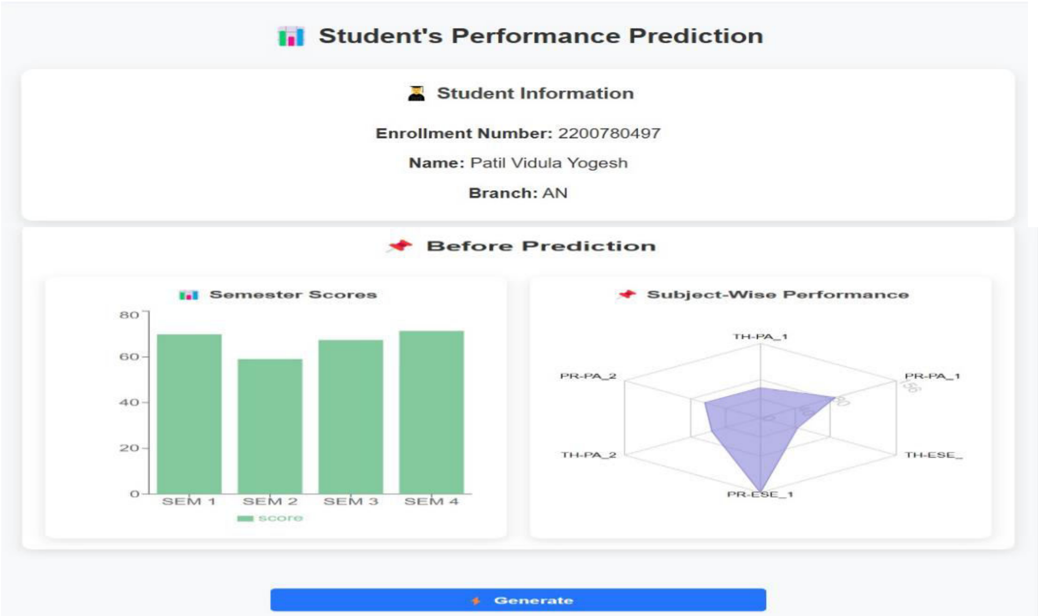
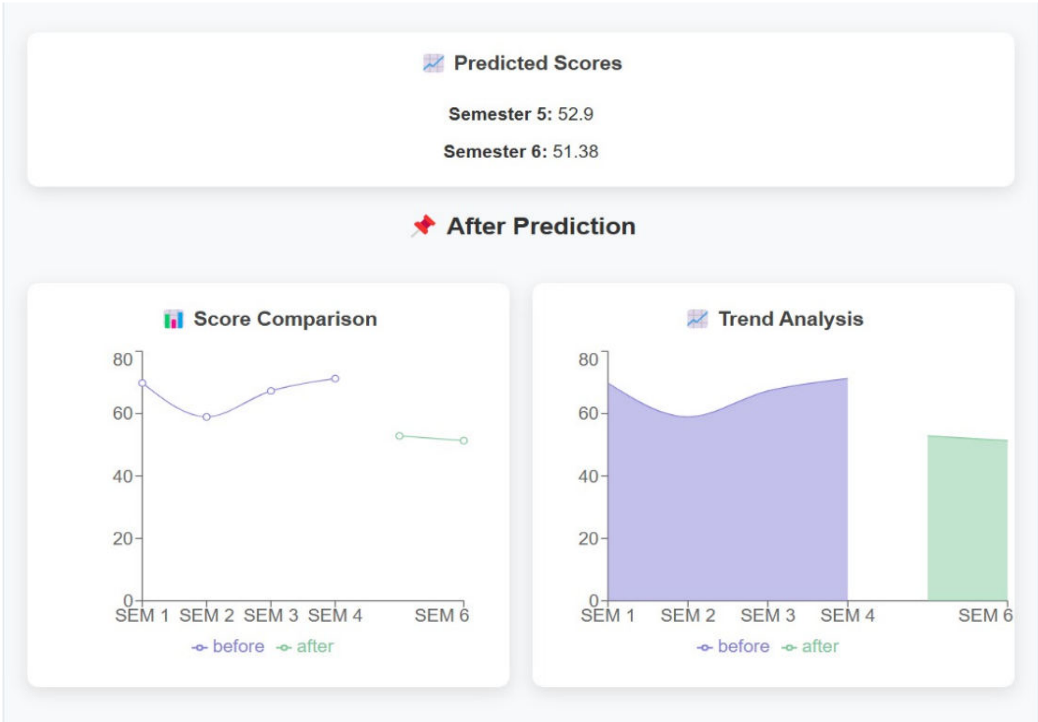
V. RESULT AND DISCUSSION





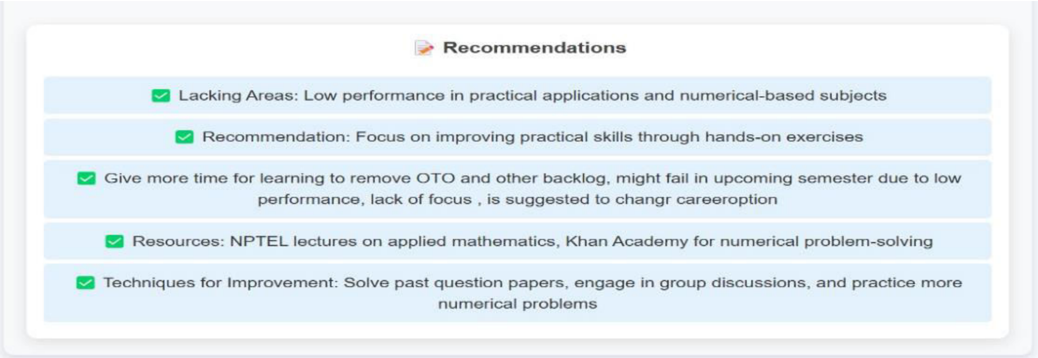


Fig.5.2 Result

Use Case: Predicting student failure rate for an OTO student

For students who fail even after the OTO provision, the system acts as a crucial tool in:

- **Early Identification of Potential Failures**: The system alerts students and educators about potential failures before the end of the semester, providing recommendations on how to avoid future backlogs or failures.
- **Customized Study Plans**: Based on individual weaknesses, the system creates personalized study improvement strategies, which could prevent further setbacks.
- **Guidance for Changing Directions**: If performance continues to decline despite multiple opportunities, the system provides suggestions for changing the academic direction or exploring alternative courses that may better suit the student's strengths.

This proactive, data-driven approach can help students like Vidula avoid repeated failures by offering personalized resources, strategies, and actionable advice in time to take corrective measures.

VI. CONCLUSION

Progresso offers a cutting-edge solution for predicting academic growth and delivering personalized learning strategies. By utilizing advanced machine learning algorithms and a seamless data integration pipeline, the system ensures accurate predictions and actionable insights for students and educators. Its user-friendly ReactJS interface, dynamic visualizations, and real-time updates make tracking academic progress intuitive and impactful.

With a cost-effective development plan and a robust feedback loop for continuous refinement, Progresso bridges the gap between traditional education and data-driven innovation. By empowering students to overcome challenges and enabling educators to make informed decisions, it sets the stage for a more adaptive and effective educational experience.

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