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Leveraging Machine Learning to Advance Higher Education for Societal Impact

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ABSTRACT: Educational institutions are progressively integrating data-driven tools to enhance student achievement and minimize dropout rates. This initiative presents a web-based system of artificial intelligence that utilizes machine learning to monitor academic performance, predict final outcomes, and identify students who may be at risk, employing essential metrics such as attendance, internal grades, and assignment scores. By recognizing issues at an early stage, the system facilitates timely and personalized interventions. Additionally, it assesses curriculum alignment by identifying inconsistencies between subject matter and academic goals, assisting educators in efficiently addressing gaps. A notable feature of the system is its implementation of a language-based AI model that provides tailored study recommendations based on the performance of individual students. The platform ensures secure login, enables data management through CRUD operations, offers real-time insights, and includes interactive dashboards. These resources empower teachers and administrators to track student progress, assess potential risks, and provide customized learning support. In summary, the system fosters improved academic results through intelligent analysis, curriculum validation, and personalized guidance.

KEYWORDS: AI in Education, Student performance prediction, Dropout Risk detection, Personalized Learning, Curriculum Validation

I. INTRODUCTION

In the current education system, monitoring student performance, spotting those at risk of failing or dropping out, and providing tailored academic support has become more difficult. Traditional evaluation methods often do not provide timely insights or personalized feedback, which can harm student success and raise dropout rates. This project presents an intelligent, AI-driven system utilizing machine learning to assess academic performance and deliver actionable recommendations. By analyzing key academic indicators like attendance, internal assessment scores, and assignment grades, the system forecasts students' overall performance and the likelihood of withdrawing, enabling prompt and focused intervention.

One important part of the system is that it can find problems related to the curriculum. It does this by looking at student records and comparing them with the goals set for each semester. This helps to find any subjects that are missing or any differences, which helps school administrators keep the curriculum on track. In addition to using predictive analytics, the system also has a recommendation engine powered by AI that gives personalized study tips. These tips help students know exactly how to improve in subjects they find difficult, adding to regular teaching with feedback that is tailored just for them. Built on a web-based platform, the system offers secure login, real-time analytics, and CRUD operations for managing student and subject information. This allows academic staff to efficiently update records, access insights, and assist students from a centralized interface. Ultimately, the project seeks to connect raw educational data with meaningful academic support by providing a unified platform for tracking, analyzing and enhancing student outcomes through intelligent insights and curriculum validation. In a fast-changing educational world, providing timely academic support for students is more crucial than ever. Traditional evaluation methods, which often rely solely on post-exam results, fall short in pinpointing students who need help. This project tackles a few major issues in education: spotting students who are having a tough time early on, offering tailored academic help, validating the curriculum, and making decisions based on data. Because of this, it stands out as a progressive and meaningful solution in the realm of smart education systems.

II. LITERATURE SURVEY

Recent developments in artificial intelligence (AI) and machine learning (ML) have enabled the creation of intelligent educational systems that support students in learning at their own pace, forecasting their performance, and receiving assistance with their assignments. Kaur et al. [1] developed an AI-based profiling system that adjusts to learners' behaviors in real time, enhancing engagement through personalization. Utilizing their Deep Reinforcement Learning model, Bagunaid et al. [2] achieved the ability to forecast academic outcomes based on visual patterns. This model provides instant feedback and surpasses traditional approaches. By effectively managing contextual information, Kulkarni et al. [3] employed a Capsule Network to improve English learning for ESL students. To categorize online students into groups, Wang et al. [4] introduced the Mixture of Experts-LSTM (MoE-LSTM) model. This model identifies students at risk of dropping out early and offers them tailored support. Gamified techniques for learning foreign languages, demonstrating increased motivation and vocabulary retention. [6] ML algorithms like Random Forest for predicting academic performance, excelling due to effective feature selection used by Li et al. [7] to choose features in noisy, multi-label educational datasets. In order to improve student performance predictions, Sakri and Saleh [8] combined logistic regression, SVM, and decision trees in the RHEM ensemble model. Deep learning was utilized by Chen et al. [9] to improve sociopolitical education by providing emotionally and cognitively relevant content. Miller et al. [10] examined coaching, fitness tracking, and ethical concerns in their review of AI's application in physical education, highlighting VR/AR integration as a potential future direction. To solve the cold-start issue and personalize course recommendations, Subha et al. [11] Deep hybrid recommendation models for customizing course recommendations and addressing the cold-start issue. In order to predict student performance in online settings, Alnasyan et al. [12] investigated deep learning models like CNNs, LSTMs, and autoencoders, highlighting the use of interpretability and fairness. A SAN-LSTM model for continuous learning analytics was introduced by Narayan and Ganapathisamy [13], who used temporal patterns to improve instruction and feedback. In order to facilitate learning in the post-pandemic environment, Pavlidou et al. [14] proposed a hybrid educational framework that blends synchronous, asynchronous, and experiential approaches. With an emphasis on boosting student engagement and encouraging moral, inclusive, and cooperative teaching methods, Almusaed et al. [15] emphasized the significance of AI in hybrid education.

III. PROPOSED METHODOLOGY

The program uses a methodical, data-driven approach to evaluate student performance, forecast future results, identify dropout-prone students, find curriculum inconsistencies, and offer AI-powered academic advice. The entire procedure is divided into different phases, each of which adds to the system's Overall effectiveness.

Step 1: Data Collection and Cleaning

Student information, including attendance logs, internal grades, and assignment scores, must be gathered and arranged at this stage. The data is formatted in a structured way appropriate for machine learning applications and goes through a cleaning process to guarantee accuracy. To guarantee high-quality data, any missing or incorrect values are fixed during this stage.

Step 2: Feature Selection and Label Creation

Key input variables include attendance percentage, internal assessment scores, and assignment grades, which serve as critical performance indicators. The final numerical grade is designated as the target variable for regression analysis, while pass/fail status or dropout risk is identified as the target variable for classification purposes.

Step 3: Model Training

Two distinct models are developed to leverage machine learning:

- A regression model is utilized to predict a student's final grade.
- A classification model is created to assess the likelihood of a student dropping out.

Step 4: Curriculum Evaluation

This step involves reviewing the courses each student is enrolled in and comparing them to the appropriate subjects for that semester. This process aids in identifying any missing or incorrect course enrollments, ensuring that students are on the correct academic trajectory.

Step 5: Predictions and Risk Assessment

When a user queries a student or semester, the system retrieves the relevant data and inputs it into the trained models. The output provides the anticipated final grade and the associated dropout risk. The algorithm utilizes these results to determine whether the student is at risk of either passing or failing, and there is a possibility of them dropping out.

Step 6: Providing Recommendations

The system generates a prompt for each subject based on the learner's performance and submits it to the OpenAI API. The response consists of tailored academic advice that reflects the student's strengths and weaknesses. These recommendations are designed to assist students in improving specific areas.

Step 7: Displaying Results and Facilitating Interaction

The results, which encompass grade predictions, risk assessments, curricular deficiencies, and AI-generated suggestions, are presented through an interactive web interface. Users can obtain real-time insights by searching using student ID or semester.

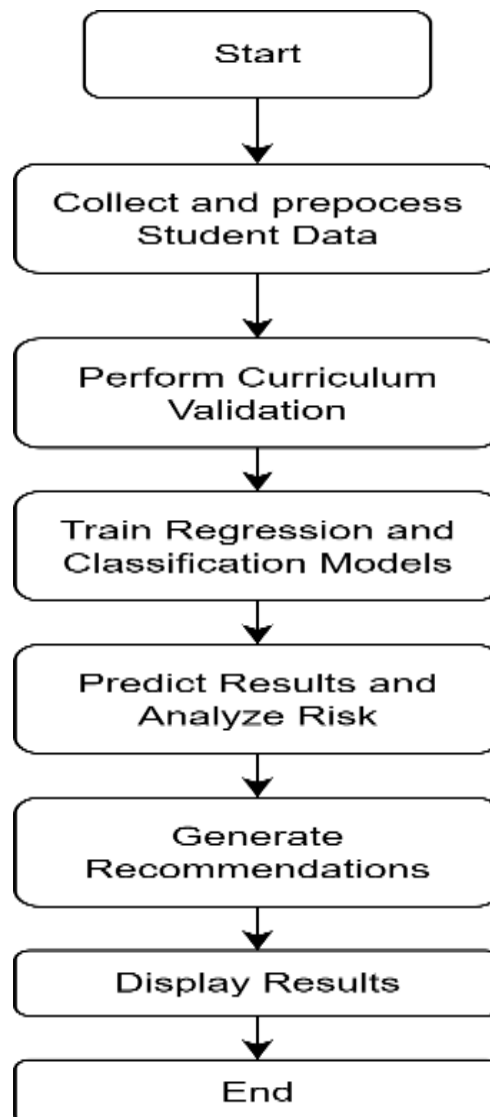


figure 3.1 : process diagram for academic performance analysis and suggestion generation

This structured methodology enables the system to analyze academic data and provide actionable recommendations, ultimately benefiting both educators and students.

The design of the AI-powered Student Monitoring and recommendation System is shown in Fig This system aims to help track academic performance, validate the curriculum, and provide personalized learning support by using machine learning and smart analytics

When an admin or faculty member logs in, the system starts employing role-based access. After logging in, the user can utilize the student monitoring and recommendation system, which is the main computer for all academic information.

The system gets information from a number of places:

- Records of students' grades, attendance, and other internal ratings.
- Entries for each semester by subject.
- We employed pre-trained machine learning models to guess grades and the likelihood of dropping out.
- Set of regulations for the curriculum that tell students what subjects they should take each semester.

The data is subsequently cleaned and prepared for analysis by preprocessing it. The ML models use this processed data to guess final grades and determine the likelihood that someone will drop out. At the same time, the system checks the curriculum by comparing the student's classes to the classes they should be taking that semester and finding any missing or incorrect entries. After making predictions and checking them, the system employs AI-based recommendation logic to make individualized academic suggestions based on how well the student is doing.

Lastly, a web interface shows the user all the information, such as performance status, risk indications, curricular gaps, and study recommendations. This finishes the process of turning data into useful academic knowledge.

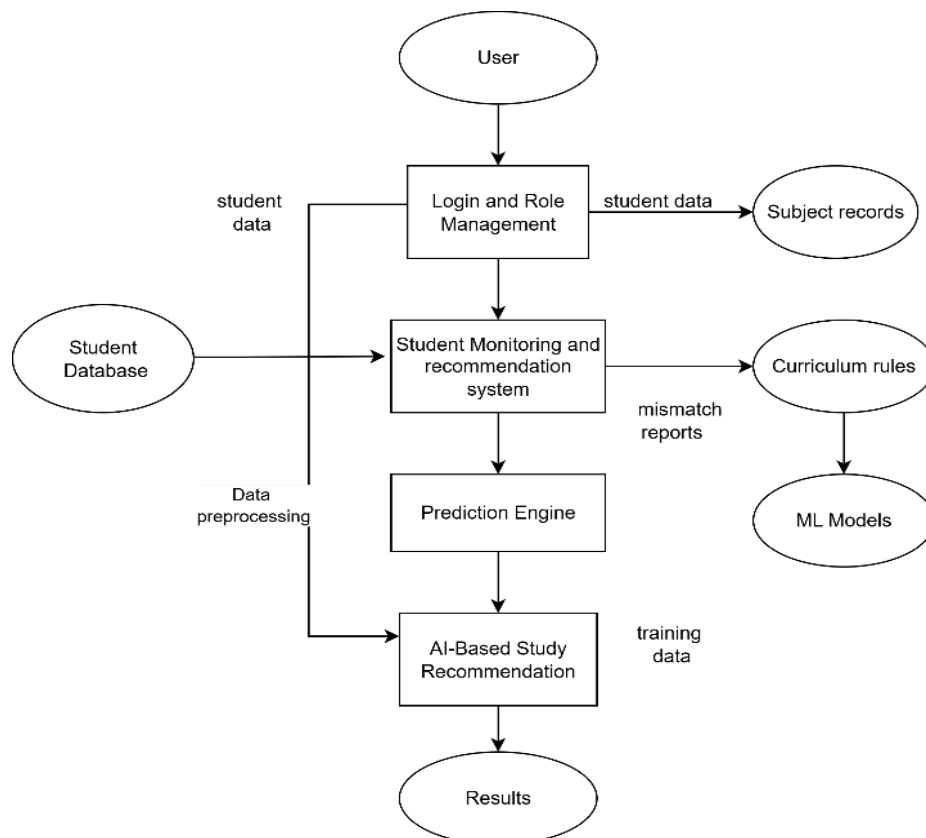


figure 3.2: Design structure for tracking student information and recommending study strategies

Through a Login and Role Management module, which ensures secure authentication and role based access, users such as administrators, instructors, and students can access the system. Users can enter or retrieve subject details and student-related data after logging in.

The Student CSV keeps important academic data such as attendance, internal assessments, and assignment scores. At the same time, Subject Records contain information about the subjects taken. Both of these data sources are sent to the main Student Monitoring and Recommendation System, which manages all the data processing and analysis.

To make sure the curriculum is being followed, the system checks student records against set Curriculum Rules. Any differences or missing information are marked as mismatch reports, which helps in making timely academic corrections. The curriculum standards and related data are also used to train Machine Learning (ML) Models.

The processed data is then sent to the Prediction Engine, which uses the trained ML models to predict students' final performance and identify possible dropout risks. The results from this engine go into the AI-Based Study Recommendations module, which creates personalized suggestions based on each student's needs.

The system's web interface allows real-time access to results, predictions, and customized recommendations. It also supports CRUD operations, enabling educational staff to manage student and subject records effectively. This combined approach promotes data-driven decision-making and creates a proactive, supportive learning environment.

IV. RESULTS AND DISCUSSION

Based on the analysis the project majorly contains three modules as explained below:

Students Module

The Student module provides a well-organized interface for managing student academic information. It shows each student's USN, name, semester, subject, attendance, scores from three internal assessments, assignment marks, and overall status. The system features options to filter records by semester, search for specific entries, and navigate through paginated results. For each student entry, you can view, edit, or delete the data. Plus, there's a "+ Add Student" button that opens a form for entering new student details into the system.

Curriculum Module

The Curriculum module is set up to manage and update the list of subjects assigned to various semesters. It features a clear table that displays each topic and its corresponding semester. Users can add new subjects or modify and delete existing ones using the action buttons provided. The module also has a searchbar and pagination tools for easy navigation and quick access to subject information.

Add Student Form

The Add Student form pops up as a window and is used to enter new student records into the system. It includes fields for the student's USN, name, semester (which can be selected from a dropdown), and subject (with a typing search feature). There are other inputs as well boxes for recording attendance, internal assessment marks (Internal1, Internal2, Internal3), and assignment scores. This structured form guarantees that all required information is collected accurately before adding a student to the database.

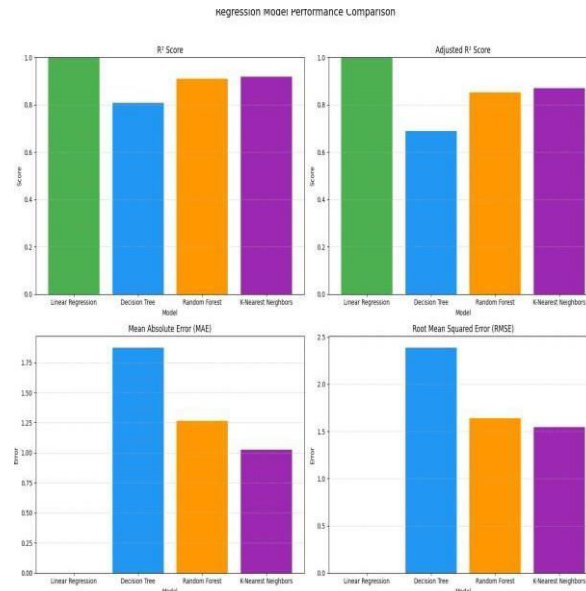


figure 4.1: model performance comparison

The image displays a regression model performance comparison using four evaluation metrics: R^2 Score, Adjusted R^2 Score, K-Nearest Neighbors, Decision Tree, Random Forest, and Linear Regression are the four models' Mean Absolute Error (MAE) and Root Mean Squared Error (RMSE).

We evaluated multiple regression algorithms to determine the most effective model for predicting our target variable. Among the metrics employed for assessment were R^2 Score, Adjusted R^2 Score, MAE, and RMSE. Linear Regression achieved perfect R^2 and Adjusted R^2 scores, but this may indicate overfitting or data leakage and should be interpreted cautiously.

- Decision Tree performed poorly across all metrics, showing the highest error values and lowest R^2 scores.
- K-Nearest Neighbors (KNN) had strong R^2 scores and relatively low MAE and RMSE, indicating decent performance.
- Random Forest consistently delivered high R^2 scores (close to 0.9) and low MAE and RMSE values, making it both accurate and reliable.

Why Random Forest is the Best Choice:

Among all the models tested, Random Forest strikes finds the ideal equilibrium between forecast precision and error minimization:

- It avoids overfitting better than Decision Tree by combining multiple trees (ensemble learning). It performs comparably to KNN in terms of error but outperforms it in R^2 scores, indicating better overall prediction power.
- Its low MAE and RMSE values verify that its forecasts are near the actual values, enhancing trust in its reliability. While several algorithms were tested, Random Forest emerges as the most robust and dependable model based on its high explanatory power (R^2), minimal prediction errors (low MAE and RMSE), and overall consistency across all metrics. Therefore, Random Forest is The ideal option for this regression task.

V. CONCLUSION

This project showcases how machine learning and artificial intelligence can be utilized to build an intelligent system that tracks student performance and supports academic decision making. The system offers helpful insights into each student's academic status by looking at significant academic factors like attendance, internal assessments, and assignment scores. It can recognize students who might drop out and predict final grades with accuracy using predictive modeling, enabling prompt and targeted intervention. By ensuring that students are on the correct academic path,

curriculum validation helps institutions uphold their standards and maintain quality.

A significant feature is the system's capability to offer personalized academic suggestions based on individual performance profiles, giving valuable feedback that encourages self awareness and targeted improvement. Accessible via a user- friendly web interface, the system allows role based access for educators, CRUD operations, real-time data analysis, and easy result visualization. Extensive testing has verified its reliability, accuracy, and readiness for real world use.

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