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Smart Student Performance Analytics and Early Warning System using Mern Stack

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Abstract: *Student performance is an important part of education. Teachers usually check students' marks, attendance, assignments, and examination results to understand their progress. In traditional systems, this information may be stored in different registers or files. Because of this, it can be difficult to identify students who need help at an early stage.*

This review paper studies how web technology, Educational Data Mining, Learning Analytics, and Machine Learning can help monitor student performance. It focuses on a proposed web application using the MERN Stack: MongoDB, Express.js, React.js, and Node.js. The system can store student details, manage attendance and marks, display performance charts, and show early warning alerts when a student may need academic support.

The paper reviews common approaches and discusses benefits, limitations, privacy, and future improvements. The proposed system is a design idea; its actual accuracy and usefulness must be tested after implementation. The main aim is to help teachers notice possible learning difficulties earlier and provide timely support..

Keywords: MERN Stack, Student Performance, Learning Analytics, Educational Data Mining, Machine Learning, Early Warning System

I. INTRODUCTION

Educational institutions collect many types of student information, such as attendance, test marks, assignment scores, and final examination results. These records can help teachers understand student progress. However, when records are maintained separately, it may take time to find patterns or identify students who are falling behind.

A student performance analytics system brings useful information together in one place. It can show marks, attendance percentages, and changes in performance. An early warning feature can highlight records that may need attention. The alert should be treated as a signal for a teacher to review the situation, not as a final judgement about the student.

II. PROBLEM STATEMENT

In some colleges, student data is managed using paper records, spreadsheets, or different software tools. Teachers may need to check multiple sources to understand a student's overall progress. Academic problems may be noticed only after the student receives low marks in major examinations.

A centralized web application can make records easier to access and can provide summaries of attendance and marks. It may also use simple rules or a validated machine learning model to identify students who could benefit from additional support.

III. OBJECTIVES

1. To study existing approaches for monitoring student performance.
2. To understand the role of Learning Analytics and Educational Data Mining.
3. To explore how the MERN Stack can be used to build a student analytics application.
4. To design modules for student records, attendance, marks, and reports.

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5. To propose an early warning feature for identifying possible academic difficulties.
6. To discuss privacy, accuracy, fairness, and future improvements.

IV. SCOPE OF THE STUDY

The paper focuses on a web-based system for college-level student records. It includes student management, attendance tracking, marks management, performance charts, reports, and possible warning alerts. The application can first use simple calculations and rules. Machine learning can be added later if a suitable dataset is available.

This paper is a review and proposed design, not a report of a completed experiment. Any prediction accuracy or improvement in student results must be measured after implementation and testing.

V. LITERATURE REVIEW

5.1 Student Performance Prediction

Researchers have studied how historical marks, attendance, and assignment results can be used to estimate student outcomes. Classification methods predict categories, such as pass or fail. Regression methods estimate a numerical result, such as marks. The quality of predictions depends on the data, selected features, and evaluation method.

5.2 Educational Data Mining

Educational Data Mining (EDM) applies data analysis techniques to educational information. It can help discover patterns in marks, attendance, course completion, and learning behavior. EDM may help institutions understand common difficulties and plan academic support.

5.3 Learning Analytics

Learning Analytics uses data about learners and their learning environment to understand and improve learning. Dashboards can display performance trends and help teachers see which students may need attention. However, attendance or online activity alone cannot fully explain a student's motivation or ability.

5.4 Early Warning Systems

Early warning systems identify possible problems before the end of a course. They may use rules, such as low attendance or missed assignments, or a trained prediction model. Alerts should be clear, timely, and reviewed by teachers before action is taken.

Overall, the literature suggests that academic data can support monitoring, but systems must be tested in the institution where they will be used.

VI. MERN STACK TECHNOLOGY

MERN is a collection of four technologies used to develop web applications. It is suitable for building a student performance system because it supports a user interface, server-side processing, and database storage.

6.1 MongoDB

MongoDB is a NoSQL database. It can store student profiles, course details, attendance records, marks, and report information in document form.

6.2 Express.js

Express.js is a backend framework for Node.js. It helps create API routes, validate requests, and connect the frontend with the database.

6.3 React.js

React.js is used to build the user interface. It can display forms, tables, charts, and dashboards for students, teachers, and administrators.

6.4 Node.js

Node.js runs JavaScript on the server. It handles application requests and supports communication between the backend and database.

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6.5 Role of Machine Learning

MERN itself does not automatically predict performance. A machine learning model must be developed separately or integrated through an API. A simple first version can use attendance and marks rules before adding a trained model.

VII. PROPOSED SYSTEM

The proposed system is a web application that allows authorized users to manage student information and review academic progress. The system can help reduce manual work and make information easier to understand.

7.1 Main Modules

- Student Management: add, view, update, and manage student profiles.
- Attendance Management: record attendance and calculate attendance percentage.
- Marks Management: store marks for tests, assignments, and examinations.
- Performance Analytics: show averages and performance trends.
- Early Warning: highlight records that meet agreed risk rules or model criteria.
- Reports: prepare student-wise and class-wise summaries.
- User Login: provide different access permissions for administrators, teachers, and students.

7.2 System Workflow

- Administrator adds student and course details.
- Teachers enter attendance and assessment marks.
- The backend checks the submitted information.
- MongoDB stores the records.
- The analytics module calculates summaries and checks warning rules.
- The dashboard displays charts, reports, and alerts.
- Teachers review alerts and decide whether support is needed.

VIII. SYSTEM ARCHITECTURE

The system follows a simple three-part flow: frontend, backend, and database. An analytics module works with the stored data and returns summaries to the dashboard.

Users
Administrator | Teacher | Student
↓
React.js Frontend
Forms, Dashboard, Charts, Reports
↓ API Requests
Node.js + Express.js Backend Validation, Login, Business Logic
↓
MongoDB Database
Student Details, Attendance, Marks
↓
Analytics Module
Summaries, Trends, Warning Alerts
↓
Output
Performance Dashboard and Reports

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8.1 Expected Output

The user can view student details, attendance percentage, marks, subject-wise performance, and warning notifications. Reports can help teachers review a class or an individual student. The system should show why an alert was generated and allow a teacher to check the record.

IX. PROPOSED METHODOLOGY

9.1 Data Collection

The system may use a sample dataset for a prototype or institution-approved student data for a real study. Possible fields include student ID, course, attendance percentage, assignment completion, internal marks, and previous results. Only necessary information should be collected.

9.2 Data Preparation

1. Check for missing or duplicate records.
2. Use consistent formats for marks and attendance.
3. Correct invalid values before analysis.
4. Protect student identity wherever possible.
5. Keep training and testing data separate if machine learning is used.

9.3 Analysis

The first version can calculate average marks, attendance percentage, and changes in performance. A simple warning rule can identify records needing review. If enough reli able historical data is available, a classification model can be trained and compared with the rule-based method.

9.4 Evaluation

The application should be tested to check that forms, reports, and database operations work correctly. For a classification model, accuracy, precision, recall, and F1-score can be reported. Results must be based on actual testing; no accuracy value should be assumed in advance.

X. ADVANTAGES

- Student records can be maintained in one place.
- Teachers can check attendance and marks more easily.
- Charts can make performance trends easier to understand.
- Reports can reduce repetitive manual work.
- Early warnings may help teachers offer support sooner.
- The application can be extended with additional modules in future.

XI. CHALLENGES AND LIMITATIONS

11.1 Data Quality

Incorrect or incomplete records can lead to incorrect reports and alerts. Data should be checked and updated regularly.

11.2 Privacy and Security

Student information must be protected. Login, role-based access, secure communication, and careful data handling are important.

11.3 Prediction Accuracy

A model can make mistakes. An alert is not a guarantee that a student will fail or succeed.

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11.4 Fairness and Human Review

Different students may have different circumstances. Teachers should review alerts before making decisions, and the system should not label or punish students automatically.

11.5 Practical Limitations

The usefulness of the system depends on available data, regular updates, teacher participation, and proper maintenance.

XII. FUTURE SCOPE

1. Add a validated machine learning model for performance prediction.
2. Provide personalized study suggestions.
3. Send alerts to authorized teachers and students.
4. Integrate with a Learning Management System if permitted.
5. Add explainable AI to show reasons behind predictions.
6. Test the system with approved real-world data and measure educational impact.

XIII. CONCLUSION

This review paper discussed how student performance analytics and early warning features can be developed using the MERN Stack. Educational Data Mining and Learning Analytics can help institutions examine attendance, marks, and other academic indicators. A web application can organize these records and display performance trends in a clear way. The proposed system includes student management, attendance, marks, analytics, reports, and early warning modules. Machine learning may be added after suitable data collection and testing. Privacy, fairness, data quality, and teacher review are important for responsible use. The system should help teachers support students, not replace human judgement.

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