

Student Performance Analysis Using - AI

Mr. Dr. Vinay S¹, Bhuvan G², Nelson A³, Harsha Nayaka D⁴, Likhith D⁵

¹Vice principal & Professor, Department of CSE, PES College of Engineering Mandya, Karnataka, India.

²³⁴⁵Students of CSE, PES College Of Engineering Mandya, Karnataka, India

Abstract - Educational institutions require a centralized platform to efficiently manage academic, administrative, and placement activities. The proposed AI-enabled College ERP system integrates student records, attendance management, teacher workloads, branch performance analysis, placement workflows, document management, and AI-based analytics into a single web-based platform. The system uses role-based dashboards, secure authentication mechanisms, structured data management, and reporting tools to support decision-making and improve operational efficiency. AI-driven analytical features assist in identifying student performance trends, academic risks, and placement readiness, enabling institutions to make informed decisions. This research paper presents the motivation, system architecture, module design, AI workflow, security mechanisms, implementation strategy, and expected institutional impact of the proposed system.

Key Words: Artificial Intelligence (AI), Student Performance Analysis, College ERP System, Machine Learning, Predictive Analytics, Educational Data Mining, Data Analytics.

1. INTRODUCTION

The proposed PES College ERP is a full-stack institutional management system designed for an engineering college environment where academic, administrative, and placement operations need to be efficiently managed and made accessible to different stakeholders according to their roles and responsibilities. Traditional college management processes often rely on spreadsheets, scattered records, manual approvals, and delayed reporting mechanisms. Such methods frequently lead to duplicate data entries, inconsistent branch information, weak traceability, and delayed identification of students requiring academic or placement support.

The proposed system addresses these challenges through a unified web-based platform with dedicated dashboards for super administrators, branch administrators, principals, Heads of Departments (HODs), teachers, students, and placement officers. The platform integrates various institutional activities into a centralized environment, ensuring better coordination and efficient management of resources and information.

In addition, the system introduces AI-assisted analytics for evaluating student readiness, faculty performance, branch-wise comparisons, and placement decision support. Rather than simply digitizing institutional forms and records, the system aims to transform organizational data into meaningful insights that can support faster and more informed decision-making processes. This approach enhances operational efficiency, improves transparency, and contributes to better academic and placement outcomes.

1.1 LITERATURE SURVEY

Educational institutions increasingly rely on technology-based systems to improve academic management, student monitoring, and institutional decision-making. Several studies have proposed ERP systems and AI-based approaches to address limitations in traditional educational management methods.

1. Educational ERP Systems

Conventional Educational ERP systems mainly focus on student registration, attendance management, examination processing, fee management, and administrative activities. These systems improve record maintenance and reduce paperwork; however, they generally lack intelligent analytical capabilities for predicting student performance and placement readiness.

2. Student Performance Prediction Using Machine Learning

Recent studies have explored machine learning techniques for predicting student performance using factors such as

attendance, academic scores, assignment completion, participation, and behavioral patterns. Algorithms such as Decision Trees, Random Forest, Support Vector Machines (SVM), and Artificial Neural Networks have been applied to identify students at academic risk and provide early intervention recommendations.

3. Artificial Intelligence in Educational Analytics

Artificial Intelligence has emerged as a significant technology in educational data analysis. AI systems help identify learning patterns, predict future performance, and provide personalized recommendations. AI-driven educational systems support faculty and administrators in monitoring student progress and improving learning outcomes.

4. Placement Management Systems

Existing placement management systems primarily automate company registration, student eligibility verification, and recruitment activities. However, many systems lack predictive analytics that can estimate placement readiness

Based on student academic records, skills, and previous placement trends.

5. Limitations of Existing Systems

Most existing systems operate independently for academic management, placement management, and performance analysis. This separation results in duplicated records, delayed reporting, inconsistent information, and limited decision-support capabilities. Additionally, traditional systems often fail to provide predictive insights required for effective institutional planning.

The proposed AI-enabled College ERP system addresses these limitations by integrating academic management, placement activities, AI-based performance prediction, role-based access control, and analytical dashboards into a unified platform. The integration of predictive analytics and decision-support mechanisms helps institutions make informed and efficient decisions

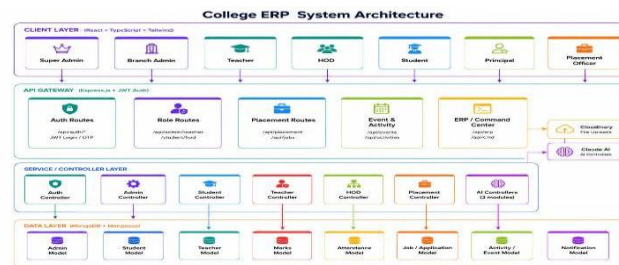


Fig: 1. High-level overview of the proposed PES College ERP platform

SYSTEM ARCHITECTURE

1.2 PROPOSED METHODOLOGY

The proposed AI-enabled College ERP system follows a centralized and role-based architecture that integrates academic management, student monitoring, placement activities, and analytical decision-support features into a single platform. The methodology is designed to improve institutional efficiency through automation and AI-driven analysis.

The implementation methodology consists of the following phases:

1. Data Collection and Integration

The system collects and stores data from multiple institutional sources, including student profiles, attendance records, academic performance, placement information, teacher activities, and departmental records. All data is maintained within a centralized database to ensure consistency and eliminate duplicate records.

2. Data Processing and Validation

The collected data undergoes preprocessing and validation to remove inconsistencies, missing values, and duplicate entries. Standardized branch names, subject details, and

Academic records are maintained to improve data quality and reliability.

3. Role-Based Access Control

The system implements role-based access mechanisms to ensure that users can access only the information relevant to their responsibilities.

The major roles include:

- Super Administrator
- Branch Administrator
- Principal
- HOD
- Teacher
- Placement Officer
- Student

Authentication and authorization mechanisms provide secure access to system resources.

4. AI-Based Analytics Layer

The AI layer processes institutional data to generate meaningful insights and predictions. Different parameters used for analysis include:

- Attendance percentage
- Internal assessment marks
- CGPA
- Backlogs
- Student activities
- Placement history
- Skill information

AI algorithms analyze these parameters to provide:

- Student risk prediction
- Placement readiness analysis
- Branch performance comparison
- Faculty performance insights
- Response pattern analysis

5. Report Generation and Visualization

The system generates reports in PDF and Excel formats for institutional review and decision-making. Interactive dashboards provide visual representations using charts, graphs, and performance indicators for easier interpretation.

6. Testing and Evaluation

The final system undergoes unit testing, API testing, role-based validation, and performance testing to verify functionality and ensure reliability under different operating conditions.

The proposed methodology transforms traditional educational management into an intelligent and data-driven system that supports academic monitoring, placement management, and institutional decision-making through AI-based analytics.

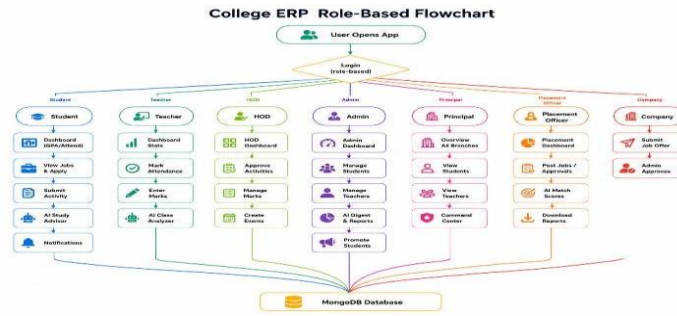


Fig-2: Layered Architecture

2. USER ROLES AND ACCESS CONTROL

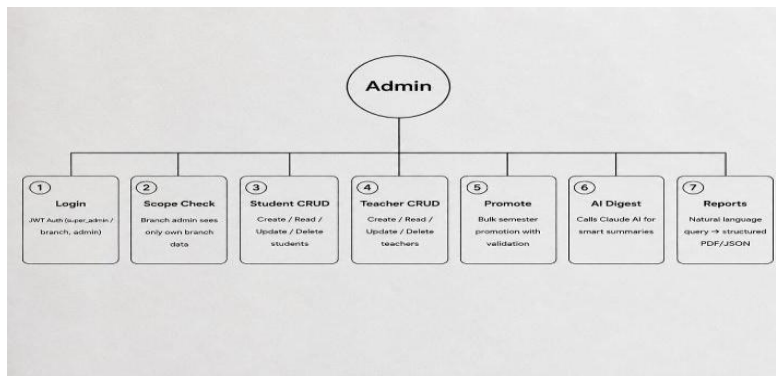


Fig-3: Admin Role Access

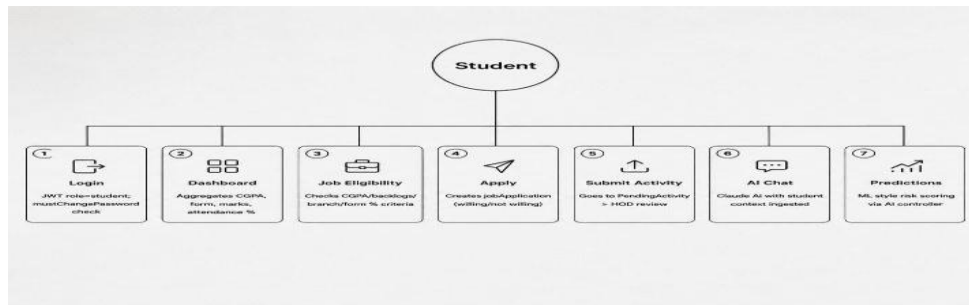


Fig-4: Student Role Access

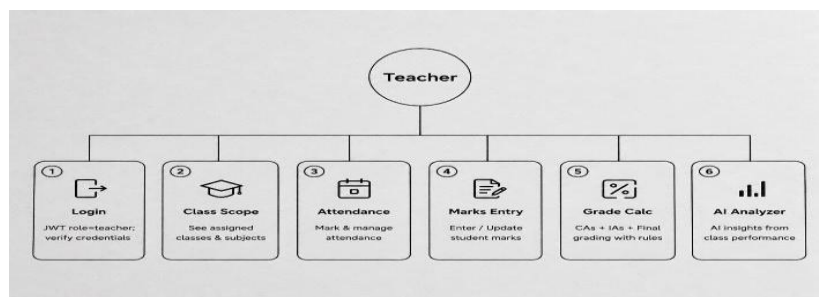


Fig-5: Teacher Role Access

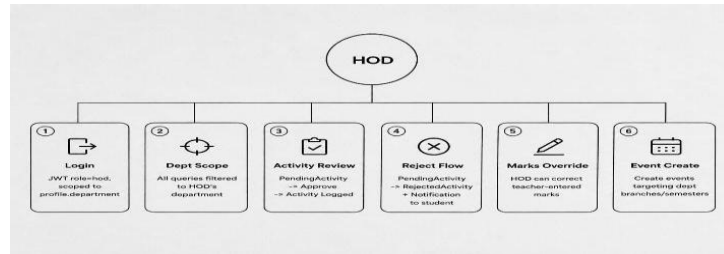


Fig-6: HOD Role Access

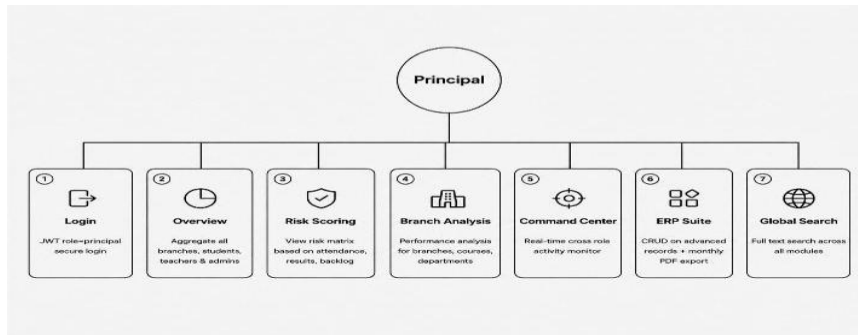


Fig-7: Principal Role Access

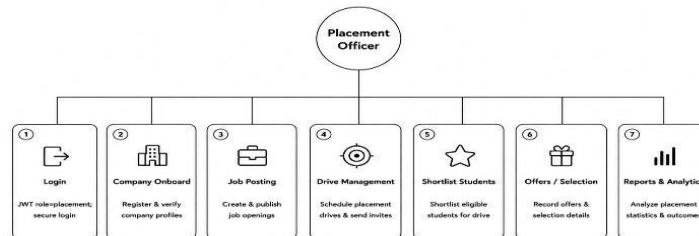


Fig-8: Placement Officer Role Access

The proposed AI-powered Carbon Footprint Estimation and Tracking System operates through a processing, machine learning prediction, and result visualization. The system is designed to estimate carbon emissions accurately and encourage sustainable practices. The process begins with user registration and login through a secure web application. After authentication, users enter activity details such as transportation usage, electricity consumption, food habits, and lifestyle patterns.

The system validates the input data to ensure accuracy and completeness.

The collected data is transmitted to the backend server using REST APIs. At the backend, preprocessing techniques such as data cleaning, normalization, and validation are applied to prepare the data for analysis. The processed data is then provided to a machine learning model, such as Random Forest Regression, which predicts carbon emissions based on user activities.

The predicted carbon footprint is calculated in terms of CO₂ emissions. Based on these values, the system assigns carbon credits, where lower emissions result in higher credits. This mechanism motivates users to adopt eco-friendly habits and reduce their environmental impact.

An AI-based recommendation engine analyses user behaviour and emission levels to generate personalized suggestions. These recommendations may include reducing fuel usage, using public transportation, minimizing electricity consumption, and adopting sustainable lifestyle practices.

All user data, emission records, carbon credits, and suggestions are stored in an SQLite database for historical tracking and analysis. The system presents the results through interactive dashboards containing graphs and charts for easy understanding of emission trends and category-wise contributions.

The system also supports real-time tracking and updates the dashboard whenever new activity data is added. In addition, historical data analysis helps identify patterns and predict future emission trends. Overall, the integration of machine learning, real-time monitoring, and intelligent recommendations makes the system an effective and user-friendly solution for carbon footprint estimation and environmental sustainability.

The system collects detailed information about user activities that contribute to carbon emissions. These activities include transportation details such as vehicle type, fuel usage, and distance travelled, electricity consumption details such as energy units used; food habits such as vegetarian or non-vegetarian diet; and lifestyle activities related to daily living. These inputs form the primary dataset used for emission estimation.

Once the data is entered, the frontend sends the information to the backend server using REST APIs. The backend server acts as the central processing unit of the system and manages communication between the frontend, machine learning model, and database. The received data is validated to ensure correctness and consistency. Invalid or incomplete inputs are filtered and corrected using preprocessing techniques.

Table1. Major User Roles and Responsibilities CORE ERP MODULES

User Role	Responsibilities
Super Administrator	Manages institution-level accounts, users, and core ERP data
Branch Administrator	Handles branch-specific operations and records
Principal	Monitors institution-level analytics and reports
HOD	Monitors department performance and activities
Teacher	Manages attendance, student records, and academic activities
Placement Officer	Handles job postings, placement activities, and AI placement analysis
Student	Accesses profile information, applications, and academic progress

Academic Lifecycle and Master Data

The Academic Lifecycle and Master Data module manages academic years, semesters, branches, sections, subjects, batches, and role definitions. Centralized master data ensures that branch names such as **CSE, ECE, ME, CE, EEE, ISE, and AIML** remain consistent throughout the ERP system, reducing data duplication and improving reliability.

Student Profile

The Student Profile module stores complete student information, including:

- Profile details
- Branch information

- Semester details
- Academic records
- Attendance status
- Activities and achievements
- Placement readiness
- Document vault entries
- Job application history

This module provides a complete view of students and eliminates the need for administrators or teachers to search across multiple records.

Teacher and HOD Modules

The Teacher module supports:

- Teacher profile management
- Subject allocation
- Attendance analytics
- Student notes management
- Weak student identification
- AI-assisted performance review

The HOD module extends these functionalities to department-level analysis and supports:

- Syllabus completion tracking
- Workload comparison
- Departmental report generation

Principal Module

The principal module provides an institution-wide overview including:

- Academic performance monitoring
- Branch comparisons
- Student and faculty performance analysis
- AI-generated summaries
- Downloadable reports

Detailed analysis becomes visible only after selecting a particular student or teacher, ensuring a clean and focused interface.

PLACEMENT MANAGEMENT

The Placement module is a major component of the proposed system and supports:

- Job creation
- Eligibility filtering
- Branch-specific targeting
- Tenth-standard marks criteria
- Deadline management
- Student response collection
- Placement record management
- Bulk data uploads
- Placement moment management
- Officer-level image deletion controls

When a Placement Officer creates a job opportunity, the system automatically distributes notifications to eligible students and branches according to predefined criteria. Students can indicate whether they are willing to participate in the recruitment process.

Response collection remains active until the specified deadline. Once the deadline expires, Placement Officers can download Excel reports containing approved or interested student lists for communication with recruiting companies.

Eligibility and Student Job Views

The Student Job Portal categorizes opportunities into the following sections:

1. Upcoming Jobs

- Displays opportunities available until the specified deadline.

2. Ongoing Jobs

- Represents active recruitment drives where interviews or assessments are in progress.

3. Completed Jobs

- Displays recruitment drives that have completed the selection process.

4. All Jobs

- Provides a complete list of current and past opportunities.

5. Not Eligible Jobs

- Displays jobs for which students do not satisfy eligibility requirements. Reasons for ineligibility may include:

- Low CGPA
- Active backlogs
- Branch mismatch
- Insufficient tenth-standard marks

The system also provides recommendations and improvement suggestions to help students become eligible for future opportunities.

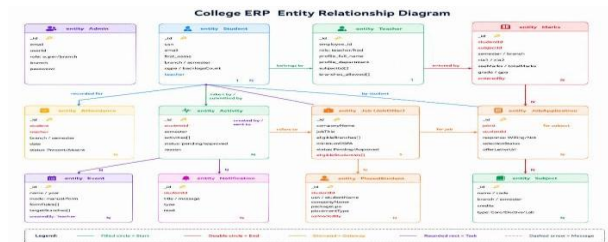


Fig-9: Entity Relationship Diagram

3. AI and Analytics Layer

The AI and Analytics layer is implemented as a decision-support mechanism that assists academic and placement activities through intelligent analysis. It combines various parameters such as academic marks, CGPA, attendance records, branch information, backlog history, extracurricular activities, placement history, company eligibility criteria, and student response patterns.

The primary objective of this module is to help faculty members identify students who may require academic intervention and to assist placement officers in understanding branch-level readiness before inviting or confirming recruitment drives. By transforming raw institutional data into actionable insights, the AI layer enhances decision-making efficiency and improves overall institutional performance.

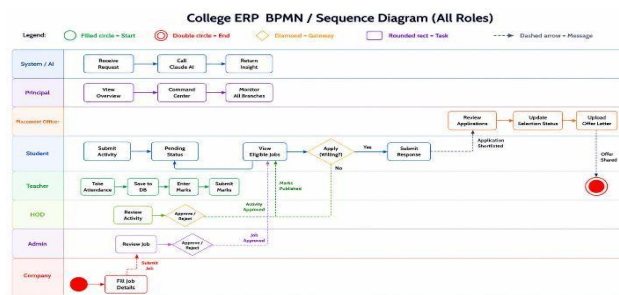


Fig-10: Sequence Diagram of all Roles

Table 2. AI Modules and Expected Outputs

Module	Inputs	Outputs	Users
Student Risk Prediction	Attendance, marks, backlog, activities	Risk level and improvement recommendations	Teachers, HODs, Principal
Placement Readiness	CGPA, skills, branch, placement history	Readiness score and company suitability	Students, Placement Officers
Branch Comparison	Student strength, results, placement data	Branch ranking and trend analysis	Principal
Teacher Analysis	Workload, class performance, notes	Faculty insights and weak area identification	Principal, HOD
Response Analytics	Willing, Not Willing, No Response	Branch-wise response rate analysis	Placement Officer

3.1 Communication and Notification System

The communication system can be extended through Email and SMS notification services. When a job opportunity is created, eligible students automatically receive notifications containing:

- Company name
- Job role
- Salary package
- Eligibility criteria
- Application deadline
- Response link

Similar notifications can also be used for:

- Attendance shortage alerts
- Event reminders
- Approval status updates
- Academic announcements
- Placement-related notifications

3.2 ADMINISTRATIVE AND SECURITY DESIGN

The administrative module supports the following functionalities:

- Student management
- Teacher management
- Bulk data uploads
- Administrator account creation
- Branch administrator editing and deletion
- First-login password modification

Temporary passwords remain visible only to authorized Super Administrators until the Branch Administrator changes the password. After the password is updated, temporary credentials are automatically removed for security

purposes.

Security mechanisms implemented in the system include:

- Authenticated routes
- Role-based access permissions
- Password hashing techniques
- Controlled file uploads
- Audit logging mechanisms

Sensitive activities such as record deletion, report export, image removal, password reset, permission modifications, and bulk data imports automatically generate audit records to maintain accountability and transparency.

Table 3. Security and Governance Controls

Security Control	Purpose
Authentication	Verifies user identity
Role-Based Access Control	Restricts unauthorized access
Password Hashing	Protects user credentials
Audit Logging	Tracks sensitive system activities
File Upload Control	Prevents unauthorized file access
Permission Management	Controls user-level operations

3.3 REPORT GENERATION

Reports play an important role in principal reviews, departmental meetings, institutional accountability, and student performance analysis. The proposed system supports downloadable PDF and Excel reports for documentation and decision-making purposes.

Student and Teacher reports may include:

- Profile information
- Branch and semester details
- Academic indicators
- Attendance statistics
- AI-generated analysis
- Performance strengths
- Risk factors
- Personalized recommendations

4. STUDIES AND FINDINGS

During the development of the proposed AI-enabled College ERP system, several existing educational management systems, placement management platforms and AI-based analytical techniques were studied. The study mainly focused on understanding institutional workflows, student performance monitoring methods, placement activities, and the role of artificial intelligence in educational environments.

The following observations and findings were identified during the study:

Studies Conducted

- Studied traditional educational ERP systems and their functionalities.
- Analyzed student performance prediction methods using Artificial Intelligence and Machine Learning

techniques.

- Examined role-based access mechanisms used in institutional systems.
- Studied placement management workflows and eligibility verification processes.
- Investigated predictive analytics approaches for identifying academically weak students.
- Reviewed security mechanisms including authentication, authorization, and audit logging.

Findings

- Traditional ERP systems mainly focus on record management and lack intelligent analytical capabilities.
- Student performance can be effectively analyzed using factors such as attendance, academic scores, CGPA, activities, and historical records.
- AI-based predictive techniques help identify students requiring academic intervention at an early stage.
- Centralized data management reduces duplicate records and improves data consistency.
- Role-based access control improves system security and restricts unauthorized access.
- Placement management becomes more efficient through automated eligibility filtering and student response tracking.
- AI-assisted decision support provides meaningful insights for teachers, HODs, placement officers, and institutional administrators.
- Report generation in PDF and Excel formats improves documentation and institutional decision-making.

Overall Finding

The study indicates that integrating Artificial Intelligence with a College ERP system can significantly improve academic monitoring, placement management, and institutional decision-making. The proposed system not only automates administrative tasks but also transforms institutional data into meaningful insights that support proactive and data-driven decisions.

5. RESULTS AND DISCUSSION

The proposed ERP system is expected to create a more transparent and efficient institutional environment where:

- Administrative users can reduce repetitive manual tasks.
- Teachers can identify academically weak students at an earlier stage.
- Placement Officers can manage recruitment activities with better eligibility control.
- Students can understand their eligibility status and identify areas requiring improvement.

Compared with traditional spreadsheet-based management systems, the proposed ERP framework provides several improvements:

- Improved data traceability
- Reduced branch-data inconsistencies
- Faster report generation
- Predictive insights for academic performance analysis
- Better placement readiness assessment

The effectiveness of the AI layer increases as institutional data continuously grows over time, resulting in improved prediction accuracy and better decision-making support.

6. Expected Outcome

The proposed AI-enabled College ERP system is expected to improve institutional management by integrating academic, administrative, and placement-related activities into a centralized platform. The system aims to reduce manual effort, improve data accuracy, and provide intelligent decision-support capabilities through AI-based analytics.

The expected outcomes of the project are as follows:

- Improved management of student, teacher, and institutional records through centralized data storage.
- Reduction in duplicate entries and inconsistencies in academic and administrative data.
- Early identification of academically weak students using AI-based risk prediction techniques.
- Better monitoring of student performance through attendance analysis, academic indicators, and activity

tracking.

- Enhanced placement management through Automated eligibility verification and response tracking.
- Improved decision-making support for teachers, HODs, principals, and placement officers through analytical dashboards.
- Increased transparency and security using role-based access control and audit logging mechanisms.
- Faster generation of institutional reports in PDF and Excel formats.
- Improved communication through notification systems for academic and placement activities.
- Enhanced overall efficiency and productivity of institutional operations.

The implementation of the proposed system is expected to transform traditional educational management processes into a more intelligent, secure, and data-driven environment that supports better academic outcomes and institutional growth.

7. Implementation Details

Table 4. Technology Stack Used in the Project

Layer	Technology	Responsibility
Frontend	React, Vite, TypeScript, ShadCN UI	Dashboards, forms, filters, charts, and user interfaces
Backend	Node.js, Express	REST APIs, authentication, file uploads, and report generation
Database	MongoDB with Mongoose	Structured data storage and management
Exports	Excel and PDF utilities	Downloadable institutional reports
AI Layer	Rule-based and statistical scoring mechanisms	Risk prediction, readiness analysis, and branch performance evaluation
Security	JWT, bcrypt, middleware	Authentication, authorization, and route protection

8. TESTING AND VALIDATION

System validation should cover frontend route accessibility, backend API permissions, bulk upload previews, branch consistency verification, PDF export functionality, Excel generation, image upload and deletion features, and password management workflows.

Build verification confirms successful frontend compilation, while backend smoke testing validates route loading and API response behavior using controlled datasets.

The following testing approaches are included:

- **Unit Testing:** Validation of eligibility rules, branch matching logic, and AI scoring functions.
- **API Testing:** Testing create, update, delete, export, and upload endpoints.
- **Role-Based Testing:** Validation for principal, super administrator, branch administrator, placement officer, teacher, and student roles.
- **Visual Testing:** Verification of dashboards and generated reports to prevent layout issues and text overlap.
- **Data Testing:** Prevention of duplicate placement records using USN, company name, and role information.

9. LIMITATIONS AND FUTURE SCOPE

Certain features depend on institution-specific policies and external services. Examples include SMS delivery systems, antivirus scanning for uploaded files, database backup mechanisms, CO/PO attainment calculations, and academic rule approvals.

The platform has been designed using extensible integration mechanisms so that these services can be incorporated without changing the existing system architecture.

Future enhancements may include:

- Two-factor authentication for administrators
- Natural language dashboard queries
- Automated parent notifications
- QR-code-based attendance systems
- Conflict-free timetable generation
- Placement brochure generation
- CI/CD deployment integration
- Advanced machine learning models trained on historical institutional datasets

10. CONCLUSION

This paper presented a complete AI-enabled College ERP framework for PES College of Engineering, Mandya. The system integrates academic management, student support services, teacher analytics, HOD and principal dashboards, placement automation, public website management, document handling, report generation, and security controls into a unified platform. By combining role-based workflows with AI-driven analytics, the proposed solution extends traditional record management systems toward institution-wide decision support, enabling improved efficiency, transparency, and data-driven decision-making.

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