Scholars Journal of Engineering and Technology

OPEN ACCESS

Abbreviated Key Title: Sch J Eng Tech
ISSN 2347-9523 (Print) | ISSN 2321-435X (Online)
Journal homepage: https://saspublishers.com

Design and Implementation of a Web-Based Student Clearance System with Administrative Analytics and Decision Support

Andrew Wisdom Nimiye[1]*, Olise Ogochukwu Favour[1]

[1]Department of Computing Sciences, Faculty of Science, Admiralty University of Nigeria, Nigeria

DOI: https://doi.org/10.36347/sjet.2026.v14i11.002 | **Received:** 17.09.2026 | **Accepted:** 12.11.2026 | **Published:** 21.11.2026

***Corresponding author:** Andrew Wisdom Nimiye
Department of Computing Sciences, Faculty of Science, Admiralty University of Nigeria, Nigeria

Abstract | **Original Research Article**

Student clearance coordinates confirmation of academic and institutional obligations across multiple offices. Paper-based and partially automated procedures can involve delays, repeated visits, fragmented records and limited visibility into request progress. This research outlines the development process of a web application which uses administrative analytics and decision support systems. The application was designed using the Agile approach and uses a three-tier architecture pattern. For the front end, the technologies used include React.js, Vite, and Tailwind CSS while for the back end, the technologies used include Node.js and Express.js. Database connectivity is enabled using Prisma ORM. Four user roles exist in this application including Student, Department Officer, Registry Officer, and Administrator. Requests pass through eight departments before final Registry authorization. Features of the system include document management, notifications, history of approvals, administrative reports, and creation of PDF clearance certificates. Features of security include JSON Web Token authentication, bcryptjs hashing of passwords, role-based security, secure API routes, server-side validation, and avoiding duplicate requests. Testing results for functional and security aspects have been found to be successful, while integration and performance tests are satisfactory. Test data included one demo student, eight departmental officers, one Registry Officer and one Administrator. The project also presents a dashboard that contains metrics on clearance and departmental activities. The project does not provide any measurement of processing times before and after processing, any quantitative measure of response time, any security audit conducted independently, or any sample of human users for acceptance; hence, the results are limited to those that are described within the project.

Keywords: Student clearance, workflow automation, administrative analytics, decision support, role-based access control, web application, higher education.

Copyright © 2026 The Author(s): This is an open-access article distributed under the terms of the Creative Commons Attribution **4.0 International License (CC BY-NC 4.0)** which permits unrestricted use, distribution, and reproduction in any medium for non-commercial use provided the original author and source are credited.

INTRODUCTION

Information and communication technology has changed administrative work across higher education. Universities use digital systems for student registration, course enrolment, results, library services, financial management and institutional records. Web-based information systems make records more accessible and support communication among students, academic staff and administrators [1]. In higher education, digital transformation has been associated with changes in service delivery and institutional processes, while adoption remains uneven across functions and institutions [2].

Student clearance is a consequential administrative process that verifies whether a student has met academic, financial, library, medical, security and other institutional obligations before graduation or issuance of academic credentials [5]. A clearance request may involve several departments, each of which must check a different obligation. In manual processes, students may visit offices one after another to obtain approvals. The project report identifies paperwork, delays, lost or fragmented records, poor communication and workload as problems associated with manual or partly automated procedures [6].

Web-based clearance systems have been developed to move request submission and departmental decisions to electronic platforms. The literature reviewed in the project describes online systems that centralize student clearance records, improve accessibility and communication and reduce paper handling [8]. The project's comparison of prior systems also identifies a

limitation: many systems emphasize transaction processing and record keeping, while offering limited reporting, departmental performance monitoring or analytical support for managers [7]. Table 1 summarizes the studies and limitations as presented in the project.

Administrative analytics and decision support extend an operational information system by organizing data into summaries, reports and indicators for review. The above-discussed literature on decision support systems explains the role of analytics in helping management plan and evaluate their decisions [9]. In relation to the student clearance case, this means that the transaction analysis system helps to link transaction history to the management control by allowing them to monitor request status, evaluate departmental performance and detect areas of processing requiring attention. However, the above-listed functions do not prove good decision making or rapid processing per se.

Database Design is Paramount for Clearance Program Involving Multiple Offices. Relational databases represent users, student records, departments, requests, approvals and supporting documents through related entities. The project adopts MySQL and Prisma ORM to store operational records and their relationships [11]. Systems-analysis and software-engineering sources support structured requirements, modular design and iterative implementation [13].

The project's research problem is the gap between electronic transaction processing and the administrative monitoring needed to understand clearance progress and departmental activity. The project is aimed at designing and implementing a web-based student clearance system that will have administrative analysis and decision support features, Automating the clearance process, Implementing authentication and role-based access control Enabling electronic submission and departmental review Implementing administrative analysis and decision support features Centralization of student data, requests, approvals, documentation, and notifications Generating certificates after final approval of the request Evaluating the efficiency of the system.

The study covers the clearance process from user registration and authentication through departmental decisions, Registry authorization and certificate generation. The project covers four positions: Student, Department Officer, Registry Officer, and Administrator. The project does not involve integration with external payment systems, learning management systems, national education databases, or biometric authentication. The development and testing was done in a controlled setting by means of simulated institution records, thus limiting the conclusions that can be drawn for wide scale implementation. This paper describes the design, implementation, and testing of the system.

Table 1: Summary of reviewed literature

Study	Focus	Major finding	Limitation
Benavides *et al.,* (2020) [1]	Digital transformation in higher education	Digital technologies improve institutional efficiency and service delivery.	Not specific to student clearance.
Laudon & Laudon (2022) [2]	Information systems in organizations	Improve data management and administrative operations.	General discussion.
Essel *et al.,* (2023) [5]	Online student clearance	Reduces paperwork and processing time.	Limited monitoring and reporting.
Mangubat *et al.,* (2023) [6]	Web-based student clearance	Improves record management and interdepartmental communication.	No analytics or decision support.
Adamu (2022) [8]	Online clearance	Improves accessibility and centralization.	Limited analytics and performance monitoring.
Taiwo & Faboya (2025) [7]	Final-year clearance	Electronic processing improves efficiency.	Primarily transaction processing.
Power & Heavin (2017) [9]	Decision support systems	Supports managerial decisions using analytics.	Not specific to clearance.
Sharda *et al.,* (2024) [10]	Business intelligence and analytics	Supports monitoring and decision-making.	General application.

MATERIALS AND METHODS

The project adopted the Agile Software Development Methodology. Agile was selected for iterative development, incremental delivery, continuous testing and refinement as requirements and interfaces were developed [14]. The project stages included requirement identification, system analysis, design, implementation, testing and evaluation. Authentication, request processing, departmental approval, analytics and certificate generation were treated as functional modules and integrated into the application.

System analysis reviewed manual and partially automated clearance procedures and compared three related online clearance systems. The analysis identified a need to combine request and approval processing with administrative monitoring. System design then defined user roles, application modules, inputs and outputs, database entities and workflow conditions. The system was organized as a three-tier architecture with presentation, application and database layers. The presentation layer serves students, officers, Registry personnel and administrators. The application layer manages authentication, approval workflow, validation,

notifications, analytics and certificate generation. The database layer stores user, student, request, approval, notification, document and history records.

The workflow starts when a user authenticates. A student submits a request; the system validates that no active request already exists and creates departmental approval records. It passes through eight administrative departments namely, Admission, Bursary, Faculty, ICT, University Library, Medical, Security and Students Affairs. The designated officers have the power to accept or deny the request together with comments. If denied, there will be notification to the student allowing him/her to correct the particular problem before submitting again. After the approval from all the eight departments, then the request will be submitted to Registry Officer for confirmation. Afterwards, the status becomes CLEARED and a PDF certificate will be issued to the student. The administrator takes care of the accounts and the system reports.

The project institutionalizes the final clearance process using eight departmental approvals process. Each decision in each department is a binary one i.e. approved or pending/denied. This results into an aggregate score based on the sum of these binary decisions. The final clearance is possible only if there are eight departmental approvals and Registry approval. The equations below reproduce this logical model from the project. This is a workflow rule, not a statistical model.

The frontend is created using React.js, Vite, and Tailwind CSS, whereas the backend uses Node.js and Express.js. The Prisma ORM is used to communicate with the database, where MySQL is the relational database management system. JWT is used to manage authentication, while the passwords are hashed by bcryptjs. Access to the system is provided based on roles. The database has entities like Users, Students, Faculties, Courses, Departments, Clearance Requests, Approvals, Documents, Notifications, and Approvals History. The software includes modules for authentication, students activities, department approvals, Registry authentication, administration, notifications, reports, and database management.

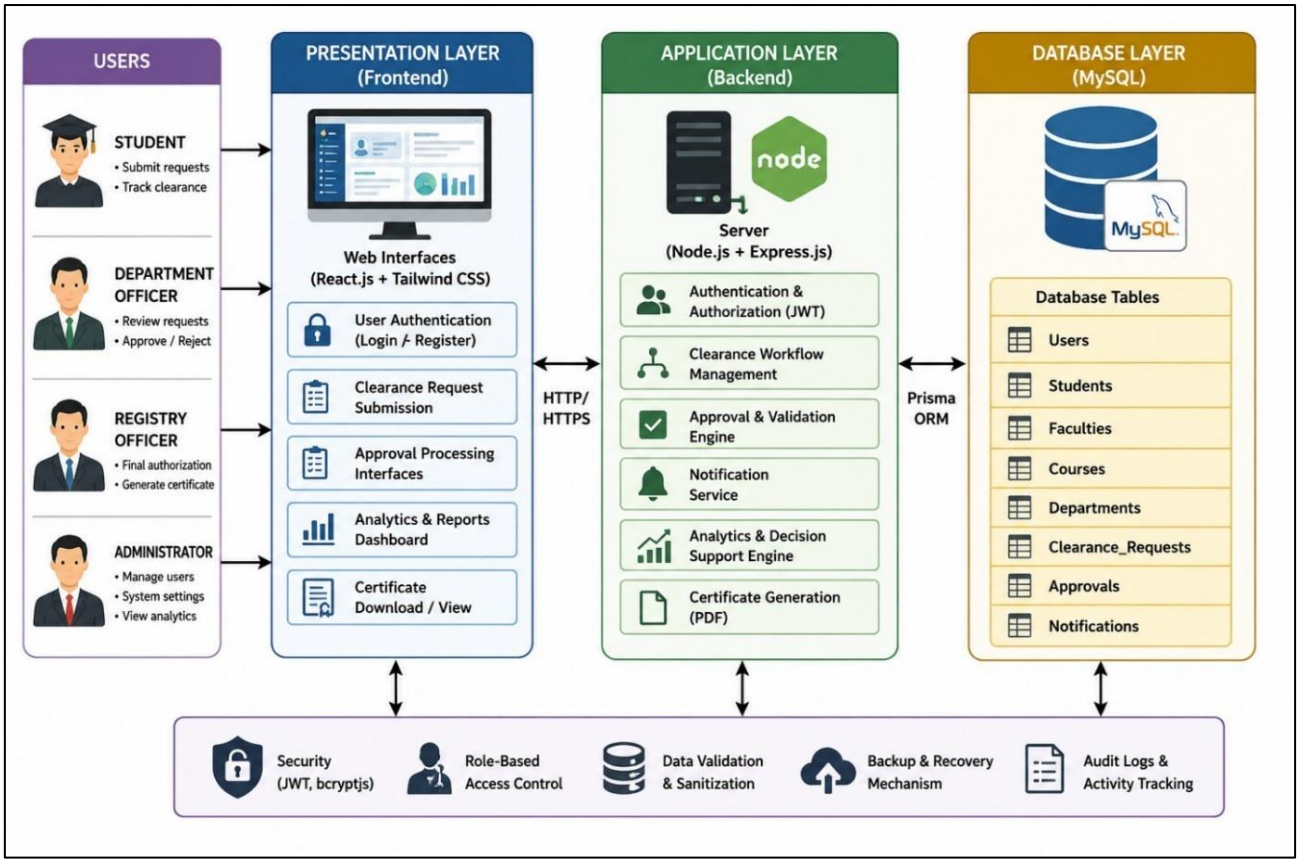


Figure 1: System architecture

This testing included functional, behavioral, integration, performance, security, and user acceptance situations. The project states that simulated test records represented one demo student, eight departmental officers, one Registry Officer and one Administrator, together with faculty, course, department, request and approval data. Table 2 shows the eight departments being evaluated. Information about the number of human users for UAT, the test period, response time, load profile, and independent validation process has not been provided in the report. Therefore, the findings will be reported in the form of test results and not usability/performance test results.

$D = \{d_1, d_2, d_3, d_4, d_5, d_6, d_7, d_8\}$ (1)

$d_i = 1$ if approved; 0 if pending or rejected (2)

$A = \Sigma_{i=1}^{8} d_i$ (3)

$0 \leq A \leq 8$ (4)

Registry verification eligibility: $A = 8$ (5)

$R = 1$ if Registry grants final approval; 0 otherwise (6)

$C = 1$ if $A = 8$ and $R = 1$; 0 otherwise (7)

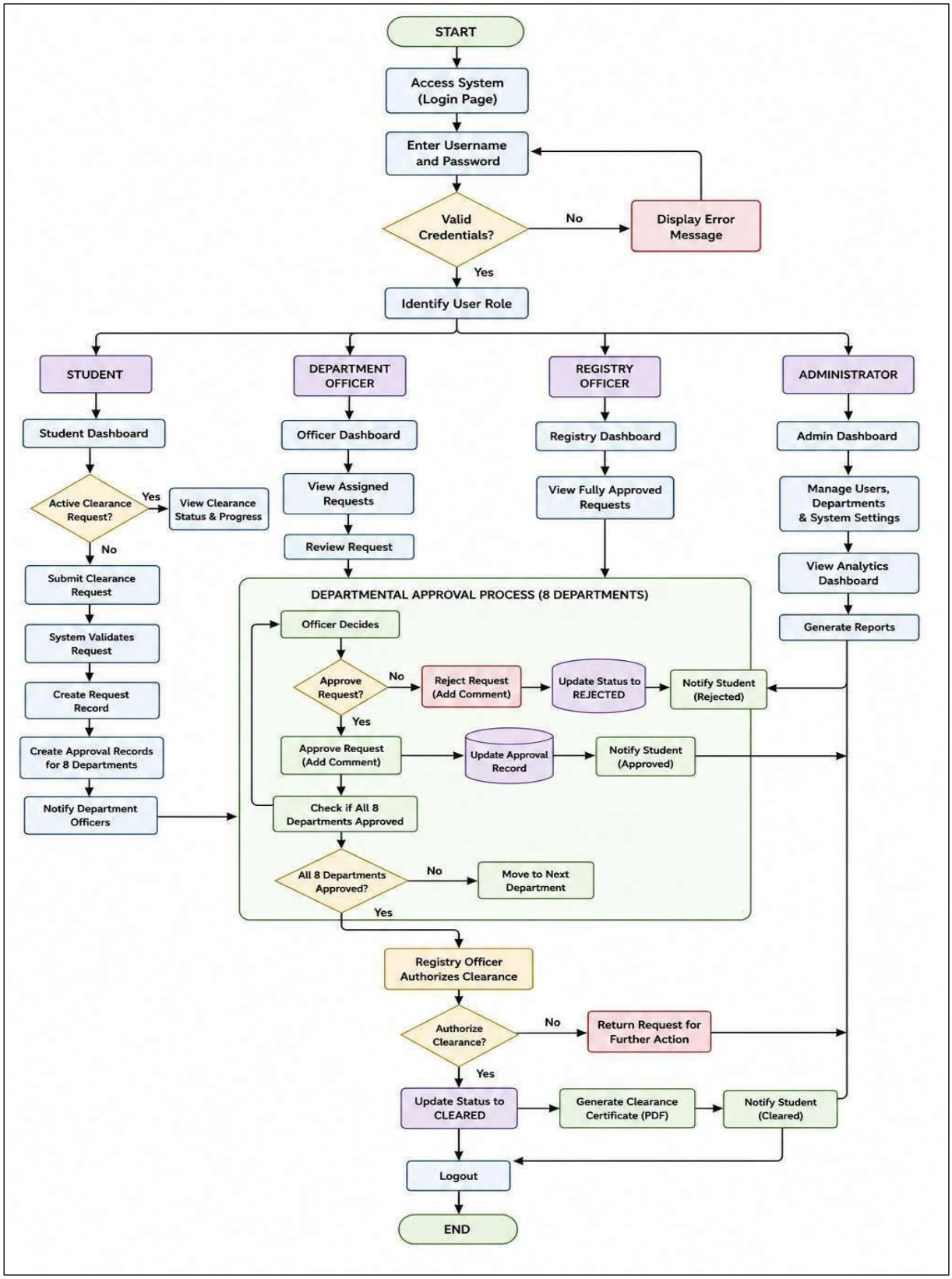


Figure 2: Clearance workflow

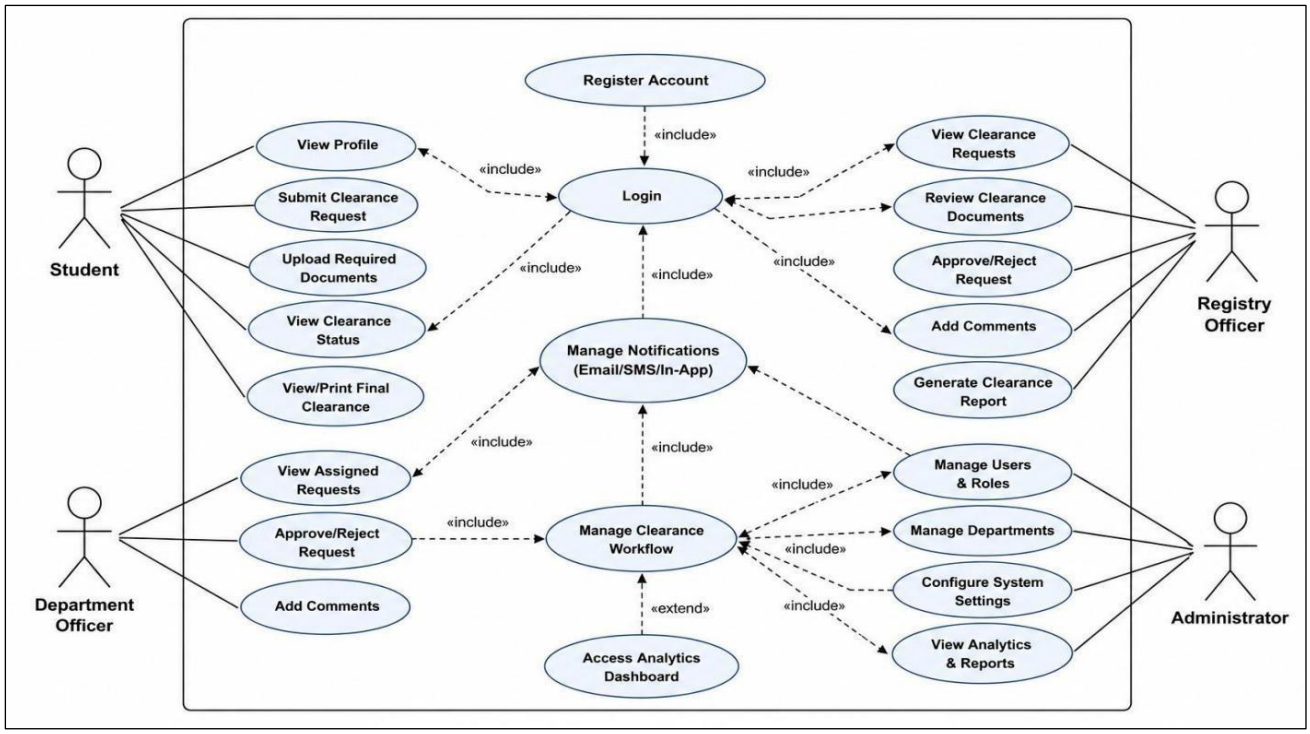


Figure 3: Use-case diagram

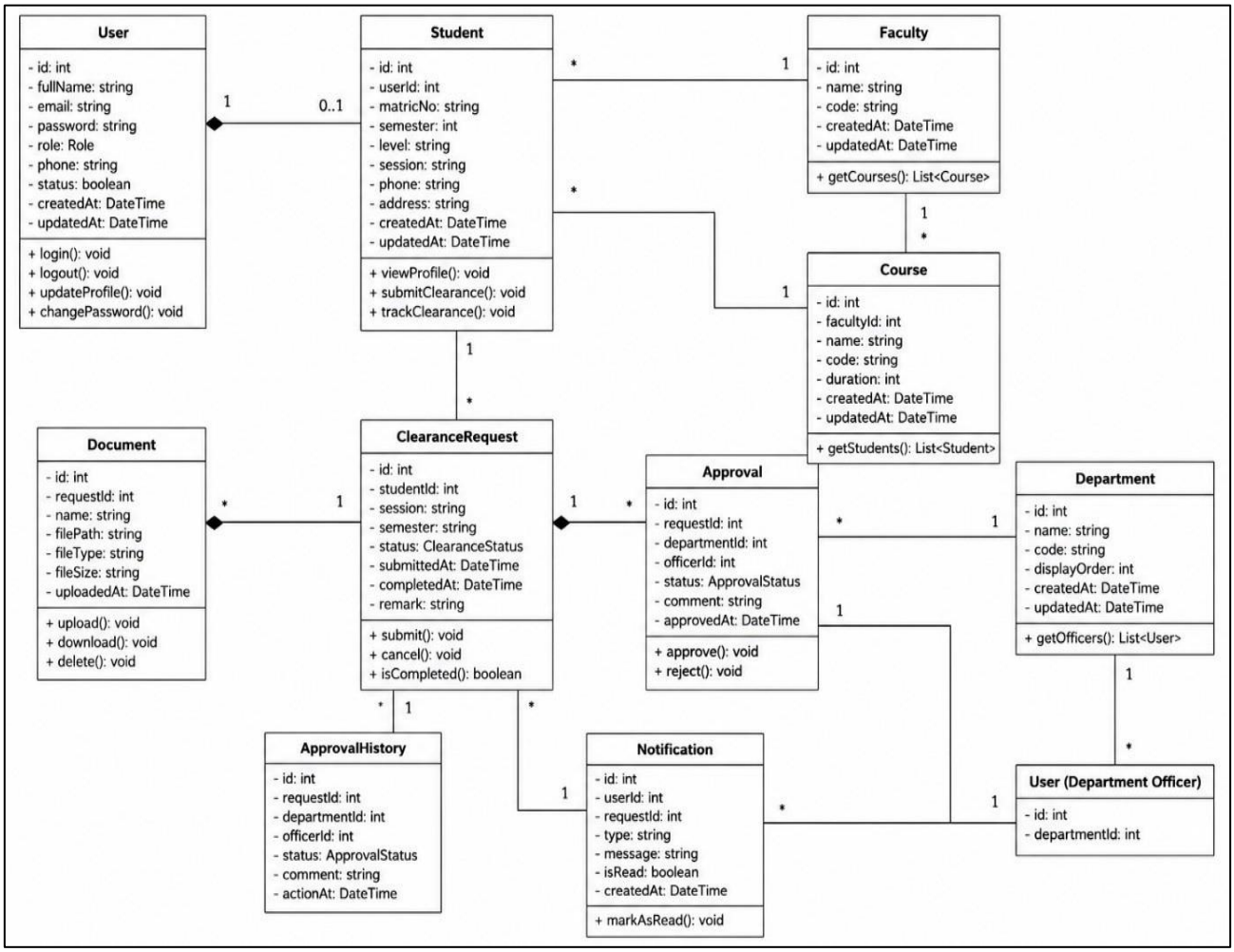


Figure 4: Class diagram

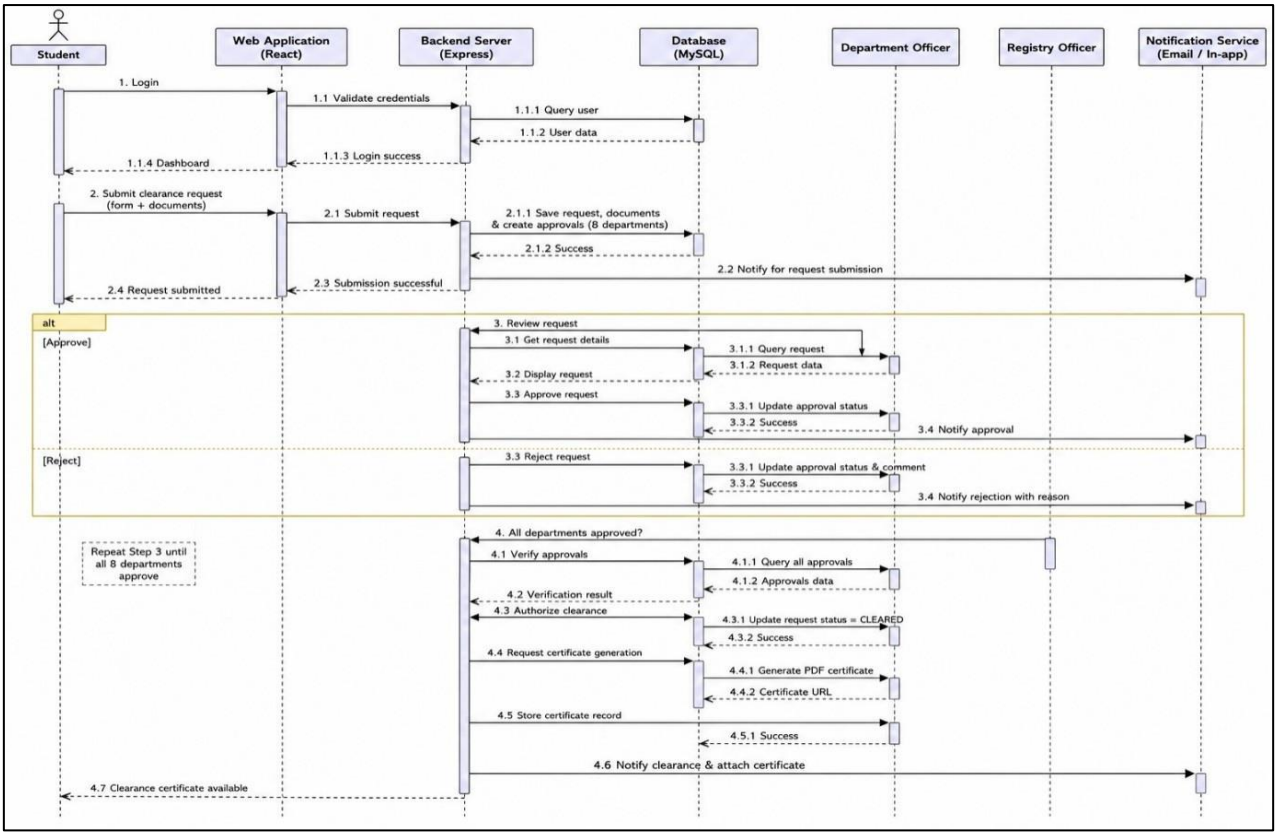


Figure 5: Sequence diagram

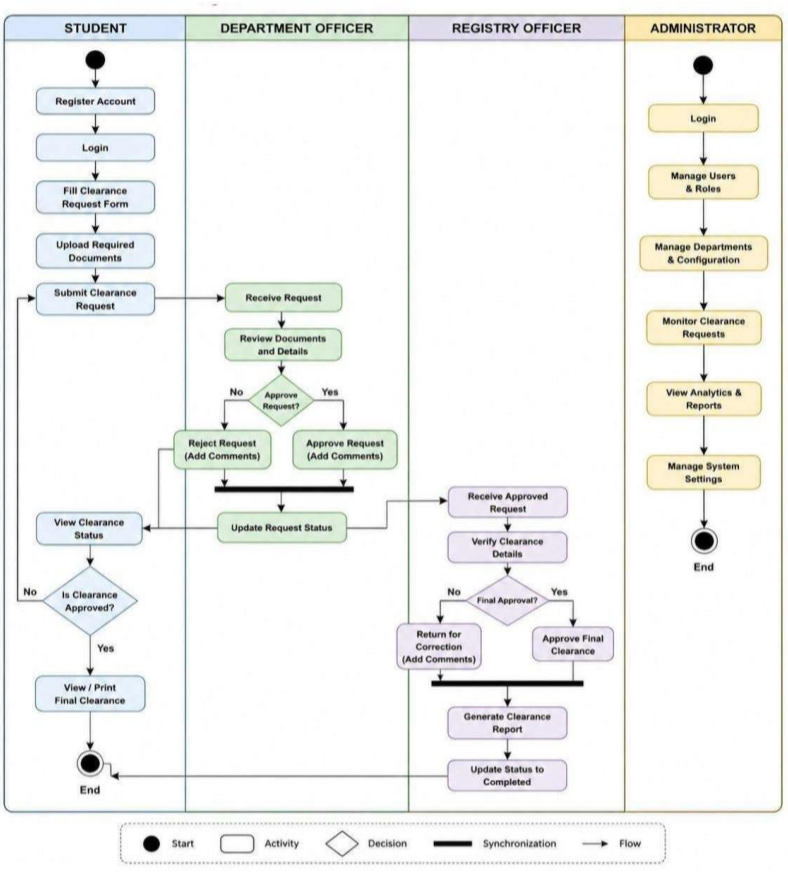


Figure 6: Activity diagram

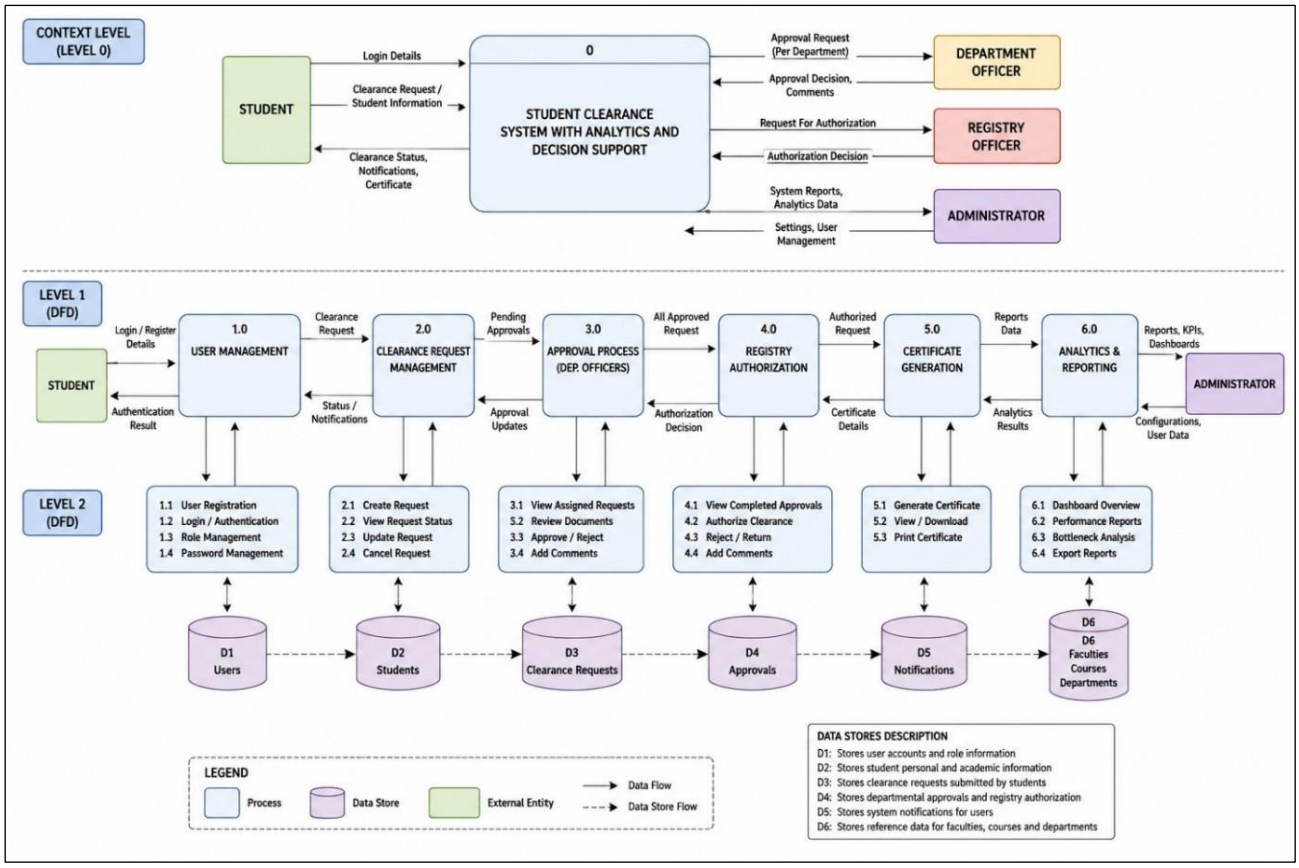


Figure 7: Data-flow diagram

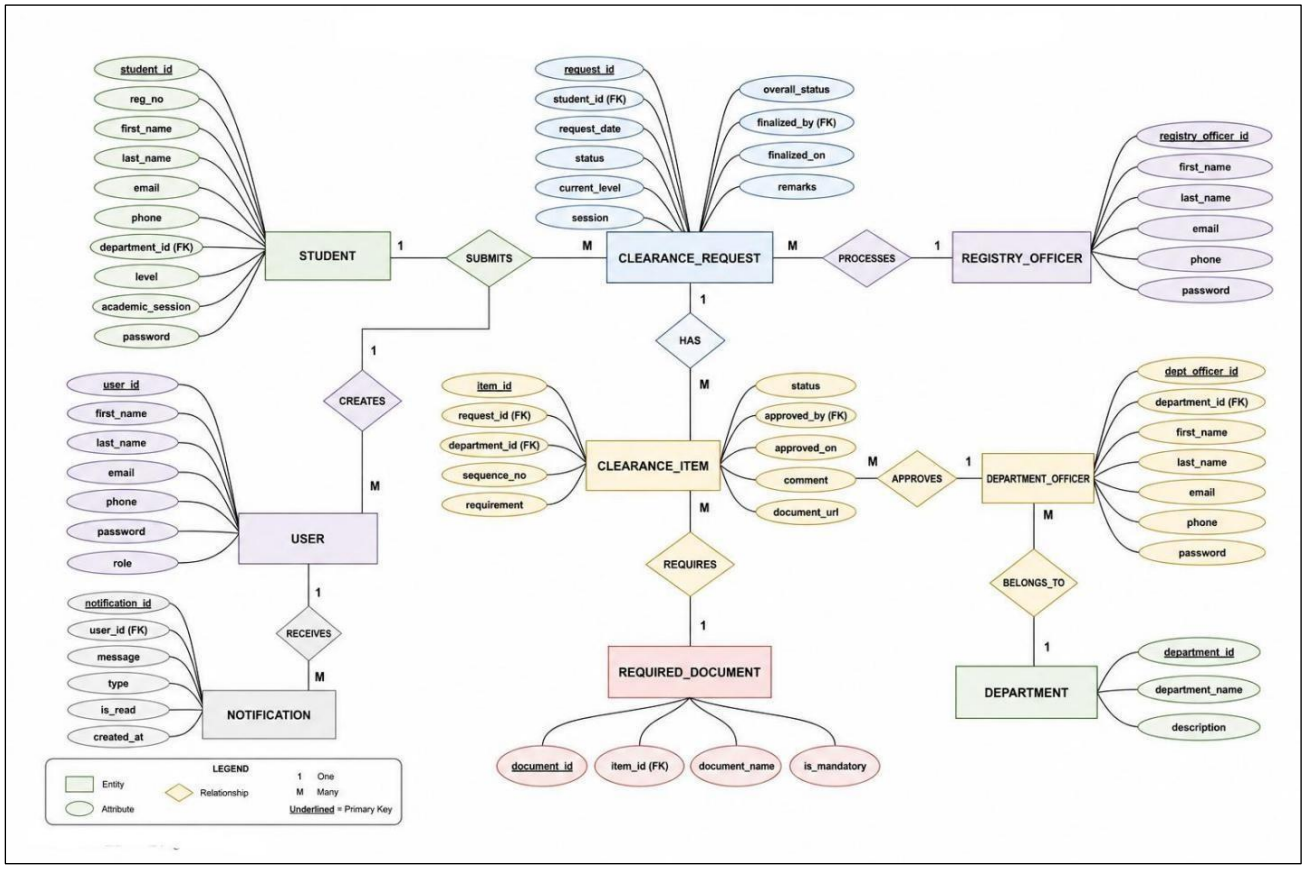


Figure 8: Entity-relationship diagram

Table 2: Major database entities

Entity	Purpose
Users	Login credentials and roles.
Students	Personal and academic information.
Faculties	Faculty records.
Courses	Programmes linked to faculties.
Departments	Eight clearance offices and assigned officers.
Clearance Requests	Student clearance applications.
Approvals	Departmental approval and rejection decisions.
Documents	Uploaded documents linked to requests.
Notifications	System-generated notifications.
Approval History	Approval actions and resubmissions for tracking.

Table 3: Application modules

Module	Description
Authentication	User authentication and secure login using JWT.
Student	Registration, requests, status tracking, uploads, notifications and certificate download.
Department Officer	Reviews and approves or rejects assigned requests.
Registry	Final authorization after departmental approvals.
Administrator	User management, activity monitoring and analytics.
Notification	Generates and displays clearance notifications.
Report	Generates certificates and administrative reports.
Database	Stores records, requests, approvals and notifications.

Table 4: Hardware requirements

Component	Minimum	Recommended
Processor	Intel Core i3 or equivalent	Intel Core i5 or higher
Memory	4 GB	8 GB or higher
Storage	128 GB HDD	256 GB SSD or higher
Display	1366 × 768	1920 × 1080
Network	Internet connection	Broadband connection

Table 5: Software requirements

Software	Purpose
Windows 10/11	Operating system
Visual Studio Code	Source code editor
Node.js	Backend runtime
React.js	Frontend framework
Express.js	Backend web framework
Prisma ORM	Database object-relational mapping
MySQL	Database management system
Git & GitHub	Version control and source management
Google Chrome	Browser for testing
Postman	API testing tool

Table 6: Development technologies

Technology	Purpose
React.js	Frontend user interface
Vite	Frontend build tool and development server
Tailwind CSS	Responsive interface styling
Node.js	Backend runtime
Express.js	Backend application framework
Prisma ORM	Database access and object-relational mapping
MySQL	Relational database
JWT	Authentication and authorization
bcryptjs	Password hashing

Table 7: User accounts used for testing

Role	Number	Purpose
Student	1 demo account	Submit requests and monitor progress.
Department Officer	8	Process assigned requests.

Registry Officer	1	Final authorization.
Administrator	1	Manage users and monitor activity.

Table 8: Departments used during testing

Department	Assigned officers
Admission	1
Bursary	1
Faculty	1
ICT	1
University Library	1
Medical	1
Security	1
Students Affairs	1

Table 9: Academic data used during testing

Data category	Description
Faculties	Faculty records for registration.
Courses	Programmes linked to faculties.
Students	Registered student records used for testing.
Clearance Requests	Sample workflow requests.
Departments	Eight offices involved in approval.

RESULTS

The implemented system provides registration and authentication, student clearance requests, document upload, status tracking, departmental approval or rejection, Registry authorization, notifications, approval history, administrative analytics and PDF certificate generation. Four role-specific dashboards support Students, Department Officers, the Registry Officer and the Administrator. Requests are routed through Admission, Bursary, Faculty, ICT, University Library, Medical, Security and Students Affairs before final Registry authorization.

The implementation uses a presentation layer, application layer and relational database. React.js, Vite and Tailwind CSS support the browser interface; Node.js and Express.js handle backend processes; Prisma ORM communicates with MySQL. The database stores user and student records, faculties and courses, departments, clearance requests, approvals, documents, notifications and approval history. Figure 17 in this manuscript shows the integrated architecture reported for the implemented system.

The project's functional test cases report passed results for student registration, login, request submission, department approval, Registry authorization, notification generation, analytics display and digital certificate generation. The security tests report passing results for password hashing, JWT authentication, role-based access, input validation and prevention of duplicate active requests. The project rates ten system performance criteria as satisfactory. The results are qualitative: the report provides no measured latency or before-and-after process duration.

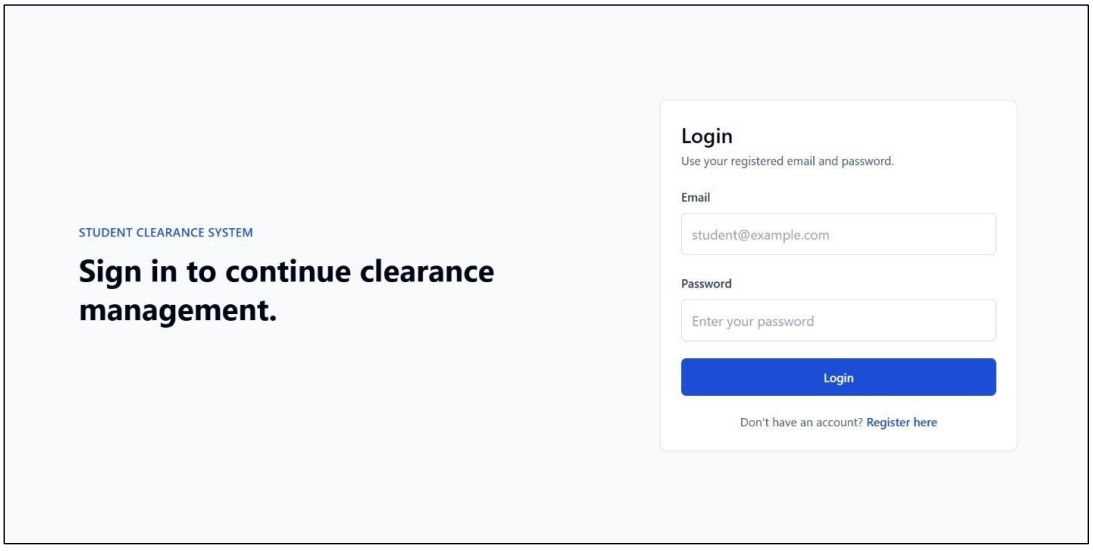


Figure 9: Login interface

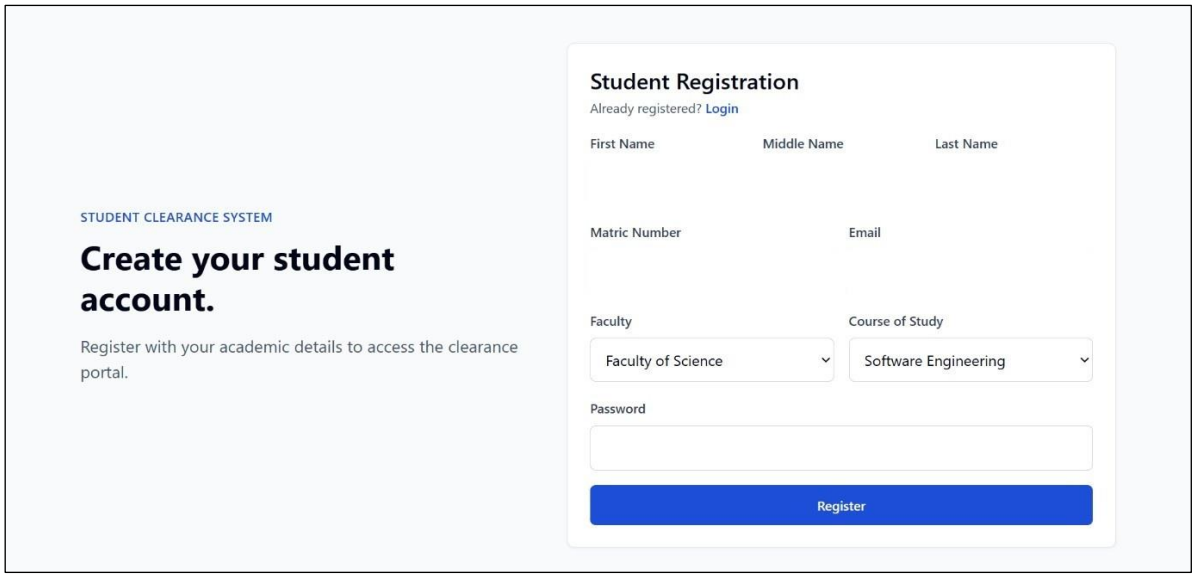


Figure 10: Registration interface

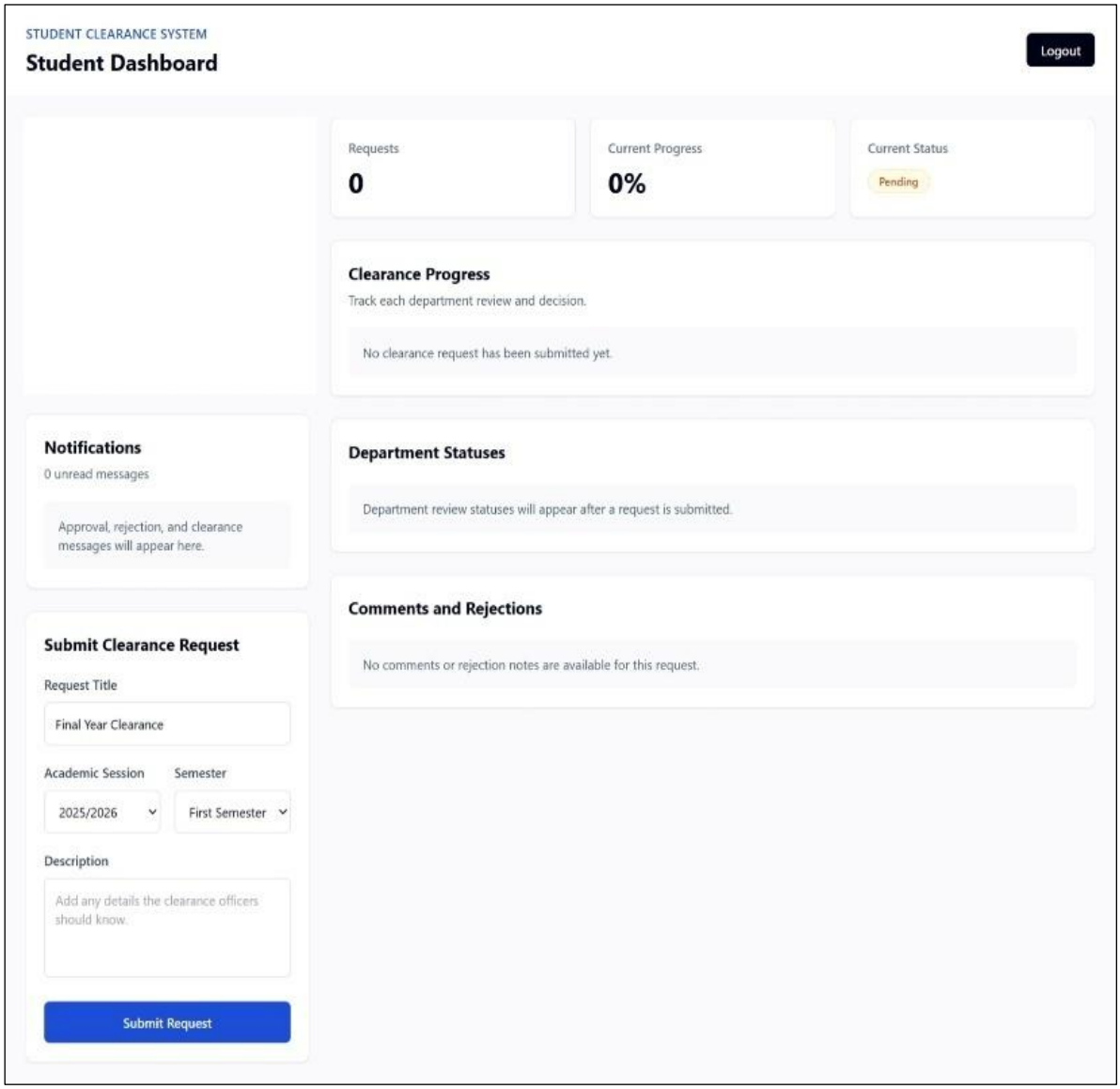


Figure 11: Student dashboard

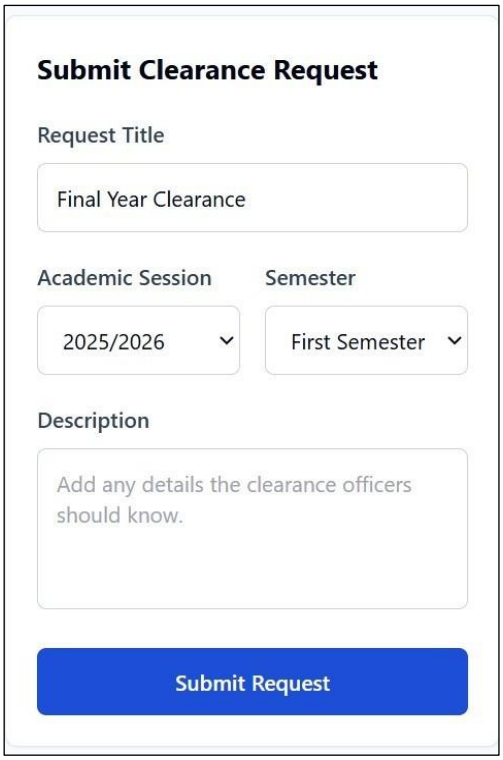


Figure 12: Clearance request form

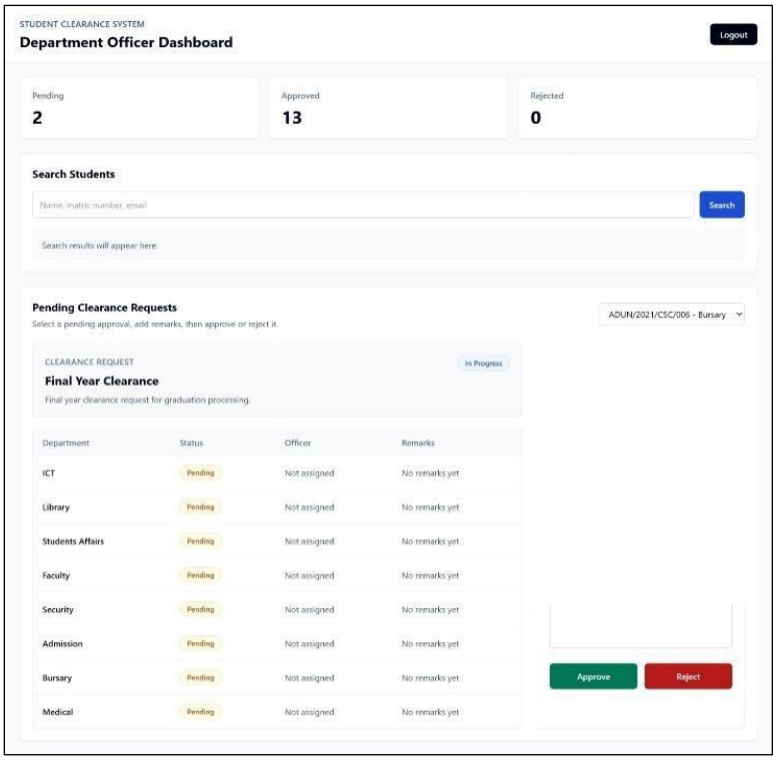


Figure 13: Department officer dashboard

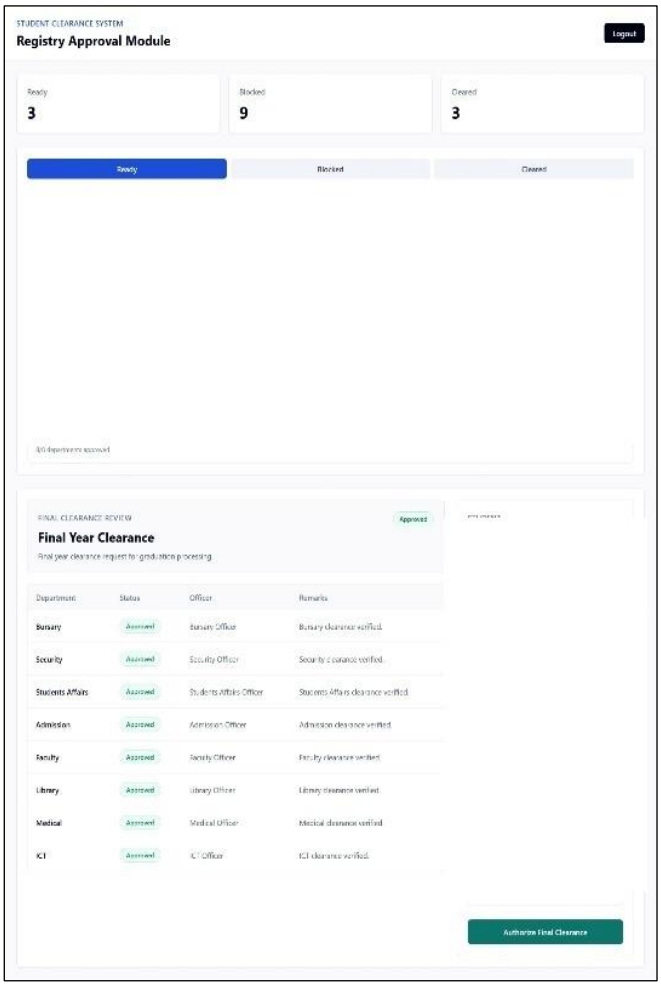
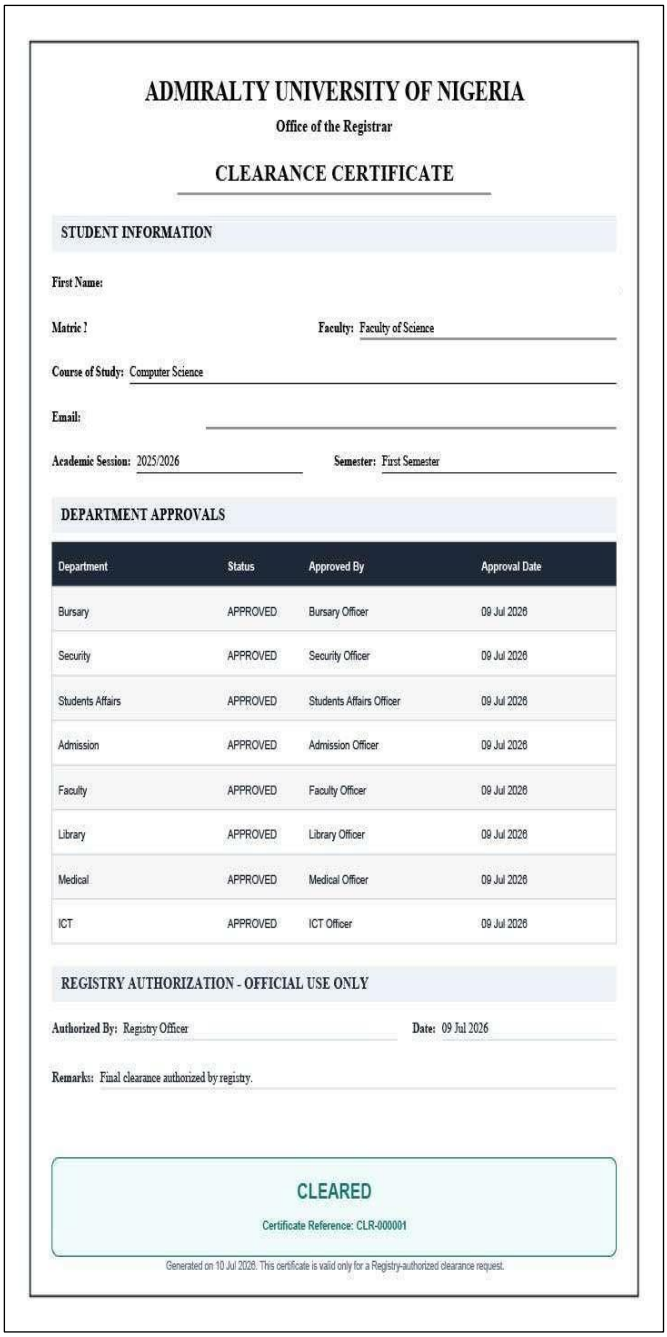


Figure 14: Registry approval module



ADMIRALTY UNIVERSITY OF NIGERIA

Office of the Registrar

CLEARANCE CERTIFICATE

STUDENT INFORMATION

First Name:

Matric ?

Faculty: Faculty of Science

Course of Study: Computer Science

Email:

Academic Session: 2025/2026

Semester: First Semester

DEPARTMENT APPROVALS

Department	Status	Approved By	Approval Date
Bursary	APPROVED	Bursary Officer	09 Jul 2026
Security	APPROVED	Security Officer	09 Jul 2026
Students Affairs	APPROVED	Students Affairs Officer	09 Jul 2026
Admission	APPROVED	Admission Officer	09 Jul 2026
Faculty	APPROVED	Faculty Officer	09 Jul 2026
Library	APPROVED	Library Officer	09 Jul 2026
Medical	APPROVED	Medical Officer	09 Jul 2026
ICT	APPROVED	ICT Officer	09 Jul 2026

REGISTRY AUTHORIZATION - OFFICIAL USE ONLY

Authorized By: Registry Officer

Date: 09 Jul 2026

Remarks: Final clearance authorized by registry.

CLEARED

Certificate Reference: CLR-000001

Generated on 10 Jul 2026. This certificate is valid only for a Registry-authorized clearance request.

Figure 15: Administrator dashboard



Figure 16: Digital clearance certificate

Table 10: Functional test results

Test	Expected result	Actual result	Status
Student registration	Account created	Created successfully	Passed
User login	Authenticate and redirect by role	Authentication completed for all roles	Passed
Request submission	Student submits request	Submitted successfully	Passed
Department approval	Approve or reject assigned items	Functions operated	Passed
Registry authorization	Only fully approved requests	Granted after all departmental approvals	Passed
Notifications	Generated automatically	Displayed correctly	Passed
Analytics dashboard	Updated statistics and reports	Updated with current data	Passed
Digital certificate	Generated after authorization	PDF generated	Passed

Table 11: Security test results

Feature	Expected result	Status
Password hashing	Passwords stored using bcryptjs	Passed
JWT authentication	Protected resources require authentication	Passed
Role-based access control	Users access authorized functions only	Passed
Input validation	Invalid data rejected	Passed
Duplicate-request prevention	No multiple active requests	Passed

Table 12: System performance evaluation

Metric	Result
User authentication	Satisfactory
Student registration	Satisfactory
Clearance request processing	Satisfactory
Departmental approval processing	Satisfactory
Registry authorization	Satisfactory
Dashboard responsiveness	Satisfactory
Notification delivery	Satisfactory
Digital certificate generation	Satisfactory
Database performance	Satisfactory
Overall system performance	Satisfactory

Table 13: Implemented security features

Security feature	Purpose
JWT authentication	Authenticates users.
bcryptjs password hashing	Hashes user passwords before storage.
Role-based access control	Restricts access by role.
Server-side input validation	Prevents invalid or malicious data.
Prisma ORM	Secure and type-safe database communication.
Protected API routes	Restricts endpoints to authenticated users.
Workflow validation	Ensures valid clearance process.
Duplicate-request prevention	Prevents multiple active requests.

Table 14: Implemented security features

Security feature	Purpose
JWT authentication	Authenticates users.
bcryptjs password hashing	Hashes user passwords before storage.
Role-based access control	Restricts access by role.
Server-side input validation	Prevents invalid or malicious data.
Prisma ORM	Secure and type-safe database communication.
Protected API routes	Restricts endpoints to authenticated users.
Workflow validation	Ensures valid clearance process.
Duplicate-request prevention	Prevents multiple active requests.

The administrator dashboard screenshot reports a single system view with 20 total students, 15 submitted requests, three cleared students (15% of registered students), 11 pending requests, one ICT bottleneck shown as 86.9 days, eight approvals beyond the five-day alert limit, and zero departments flagged for rejection rate. The project specifies a bottleneck when approval time exceeds five days and a department flag when rejection rate exceeds 30%. The screenshot has no timestamp, reporting period or data-collection description; its values are retained as displayed and are not treated as representative institutional estimates.

Table 15: Administrator dashboard summary values transcribed from the project screenshot

Indicator	Value displayed
Total students	20
Clearance requests submitted	15
Cleared students	3 (15% of registered students)
Pending requests	11
ICT bottleneck	86.9 days
Pending approvals beyond 5-day limit	8
Departments flagged for rejection rate	0

Table 16: Department statistics displayed in the administrator dashboard

Department	Approvals	Pending	Rejected	Performance
Bursary	13	2	0	87%
Admission	13	2	0	87%
Security	13	2	0	87%
Faculty	11	4	0	73%
Medical	8	**1. 7**	0	53%
Library	6	8	1	40%
Students Affairs	6	9	0	40%
ICT	6	9	0	40%

Table 17: Monthly values shown in the dashboard trend chart

Month	Requests submitted	Finally cleared
February	0	0
March	0	0
April	5	0
May	8	0
June	2	3
July	0	0

Table 18: Request-status distribution displayed in the dashboard

Status	Count
Pending	0
In progress	8
Approved	3
Rejected	1
Cleared	3
Cancelled	0

Table 19: System documentation components

Type	Description
Technical documentation	Architecture, source code, database, APIs, installation and maintenance.
User documentation	Instructions for user roles.
Installation guide	Installation, dependencies and database setup.
Database documentation	Tables, relationships and constraints.
Maintenance guide	Updates, backups, troubleshooting and enhancements.

Table 20: Types of system maintenance

Type	Purpose
Corrective	Correct software defects.
Adaptive	Accommodate institutional or technology changes.
Perfective	Improve performance, usability and functionality.
Preventive	Reduce failures through updates, backups, patches and monitoring.

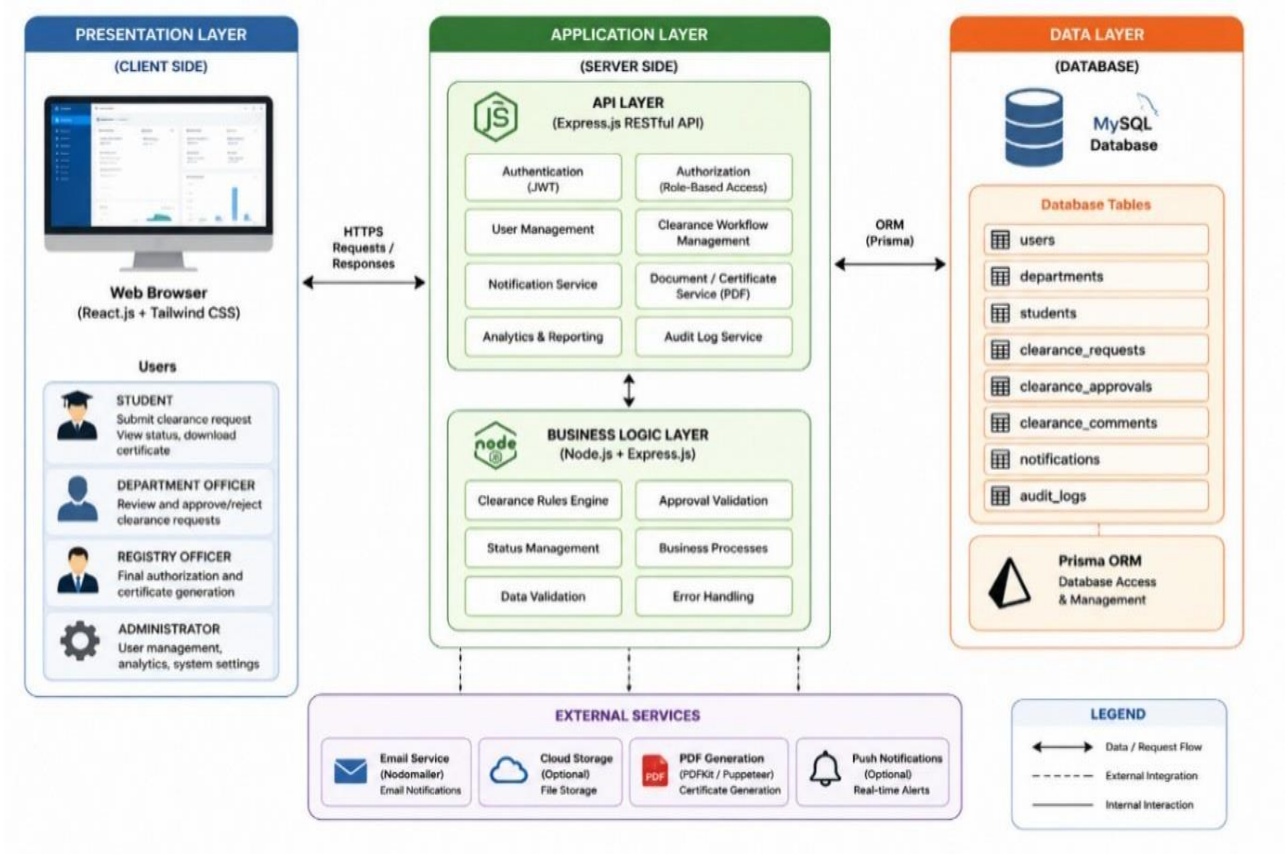


Figure 17: Integrated system architecture

DISCUSSION

The system addresses the project's stated problem by combining digital request processing with a role-based, multi-office approval workflow. Its eight departmental decisions and Registry authorization are represented in the workflow model, and the application prevents final clearance until all departments have approved. This establishes a defined process path within the implemented system. The project did not compare the application's completion time with a measured paper-based baseline, so reductions in processing duration or administrative workload cannot be quantified from the reported results.

The administrative analytics dashboard extends the workflow by displaying request counts, status, monthly trends, department-level performance and rule-based alerts. Its ICT alert illustrates how an approval-delay threshold can surface a department for administrator review. However, the dashboard screenshot is a single view without a stated period or validation sample. The project does not report the underlying calculation for every indicator, the alert's accuracy, or whether administrators changed decisions in response. The listed dashboard values therefore demonstrate interface output, not validated administrative impact.

The functional test table and security test table indicate that the specified operations were exercised and passed in the project's test setting. The stated test accounts include one demo student, eight department officers, one Registry Officer and one Administrator; the report also states that sample faculty, course, request and approval records were used. The user-acceptance section describes scenarios across roles but does not identify a human participant count or a survey instrument. Performance is described as satisfactory but lacks timed measurements, test load or hardware configuration tied to the reported result. These limits constrain claims about usability, scalability and efficiency.

The implementation combines a three-tier application architecture with centralized relational data storage. The described security measures include JWT authentication, bcryptjs password hashing, role-based permissions, server-side validation, protected routes, Prisma-managed database access and duplicate-request prevention. The project reports those security test cases as passed, but does not describe an independent penetration test or external review. Similarly, the report identifies the system as developed and evaluated in a controlled environment and notes that external institutional integrations and multi-institution deployment were outside the study scope.

The project's literature review identifies a gap in administrative analytics within clearance systems and uses this as the rationale for combining workflow automation and dashboard reporting. Its contribution is

therefore the integrated design and implemented system described here. The evidence supports a software implementation with reported functional test outcomes. Further evaluation would require defined data periods, measured approval times, documented test participants, operational deployment and comparison of dashboard alerts with verified records. Those additional measurements are not available in the project and have not been added to this manuscript.

CONCLUSION

The project designed and implemented a web-based student clearance system with four user roles, an eight-department approval process, final Registry authorization, notifications, document management, approval history, administrative analytics and PDF certificate generation. Functional and security test cases are reported as passed, while integration and performance are rated satisfactory. The administrator dashboard presents clearance counts, departmental summaries and rule-based alerts, including an ICT delay value in the supplied snapshot.

The project supports conclusions about implemented functionality in its described controlled test setting. It does not provide quantitative evidence of processing-time reduction, response-time performance, alert accuracy, user satisfaction or large-scale deployment. Future evaluation should document a defined participant sample, baseline process measures, operating period, underlying dashboard calculations and verified alert outcomes.

Acknowledgement

The authors thank their project supervisor, Dr. Okafor Patrick Naemek, the Head of Department, Prof. Daniel Asuquo, Course Advisor Mr. E. Bernard, and the lecturers and staff of the Department of Computing Sciences, Admiralty University of Nigeria, for their guidance and support during the project.

REFERENCES

- Benavides, L. M. C., Tamayo Arias, J. A., Arango Serna, M. D., Branch Bedoya, J. W., & Burgos, D. (2020). Digital transformation in higher education institutions: A systematic literature review. Sensors, 20(11), Article 3291. https://doi.org/10.3390/s20113291
- Laudon, K. C., & Laudon, J. P. (2022). Management information systems: Managing the digital firm (17th ed.). Pearson.
- Ajani, O. A. (2024). Exploring digital transformation and future trends in higher education development across African nations. Journal of Pedagogical Sociology and Psychology, 6(3), 34-48. https://doi.org/10.33902/jpsp.202427374
- Mabotha, P. A. P., & Ngcamu, B. S. (2026). Digital transformation in the higher education sector: A systematic literature review. Administrative Sciences, 16(1), Article 1. https://doi.org/10.3390/admsci16010001
- Essel, D. D., Techie-Menson, H., Oppong, S. O., & Alakuu, A. (2023). Digitalising the clearance processes of higher education institutions through the design and implementation of an online clearance system. International Journal of Scientific Research and Management, 11(7), 42-58. https://doi.org/10.18535/ijsrm/v11i07.as01
- Mangubat, J. M. L., Reubal, K. V. P., Caluya, J. F. M., Pepito, J. K. B., Catungal, M. L. P., & Encarnacion, P. C. (2023). Online student clearance management system. International Journal of Science and Applied Information Technology, 12(5), 38-43. https://doi.org/10.30534/ijsait/2023/011252023
- Taiwo, O., & Faboya, O. T. (2025). Automated final year online clearance system: A case study of a university. Iconic Research and Engineering Journals, 9(3), 318-326.
- Adamu, A. (2022). Online clearance system. FUDMA Journal of Sciences, 6(2), 283-291. https://doi.org/10.33003/fjs-2022-0602-1756
- Power, D. J., & Heavin, C. (2017). Decision support, analytics, and business intelligence (3rd ed.). Business Expert Press.
- Sharda, R., Delen, D., & Turban, E. (2024). Business intelligence, analytics, data science, and AI: A managerial perspective (5th ed., Global ed.). Pearson.
- Dennis, A., Wixom, B. H., & Tegarden, D. (2020). Systems analysis and design: An object-oriented approach with UML (6th ed.). Wiley.
- Elmasri, R., & Navathe, S. B. (2016). Fundamentals of database systems (7th ed., Global ed.). Pearson.
- Beck, K., Beedle, M., van Bennekum, A., Cockburn, A., Cunningham, W., Fowler, M., Grenning, J., Highsmith, J., Hunt, A., Jeffries, R., Kern, J., Marick, J., Martin, R. C., Mellor, S., Schwaber, K., Sutherland, J., & Thomas, D. (2001). Manifesto for Agile software development. https://agilemanifesto.org/
- Schwaber, K., & Sutherland, J. (2020). The Scrum guide: The definitive guide to Scrum - The rules of the game. https://scrumguides.org/docs/scrumguide/v2020/2020-Scrum-Guide-US.pdf
- Pressman, R. S., & Maxim, B. R. (2020). Software engineering: A practitioner's approach (9th ed.). McGraw Hill. Sommerville, I. (2016). Software engineering (10th ed.). Pearson.