

**UNIFIED EXAMINATION MANAGEMENT SYSTEM (UEMS): A CASE STUDY OF
DEPARTMENT OF COMPUTING AND TECHNOLOGY, UGANDA CHRISTIAN
UNIVERSITY**

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**A PROJECT REPORT SUBMITTED TO THE FACULTY OF ENGINEERING, DESIGN AND
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UGANDA CHRISTIAN UNIVERSITY**

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**UGANDA CHRISTIAN
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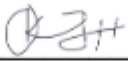
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Declaration

We, the undersigned, hereby declare that this report titled Unified Examination Management System (UEMS): A Case Study of Uganda Christian University is our original work. It has not been submitted for any other degree award at any other university or institution. All sources of information used have been duly acknowledged in the references section.

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Dedication

To Almighty God, for His endless grace, guidance, and strength that carried us through every challenge of this academic journey.

To our beloved parents and families, for your countless sacrifices, unwavering belief in us, and the encouragement you provided even when the path seemed difficult. Your prayers, patience, and moral support have been our greatest source of strength.

To our lecturers and supervisors, for your dedication to shaping not just our minds but our character, and for pushing us to achieve more than we thought possible.

To our friends and classmates, for the late-night discussions, shared laughter, and the camaraderie that made this journey bearable and memorable.

This work is as much yours as it is ours.

Joseph, Emelda, and Robert

March, 2026

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Abbreviations

Abbreviation	Meaning
EMS	Examination Management System
ERP	Enterprise Resource Planning
ICT	Information and Communication Technology
KPI	Key Performance Indicator
LMS	Learning Management System
ML	Machine Learning
MTAT	Mean Turnaround Time
MVP	Minimum Viable Product
MVC	Model-View-Controller
OMR	Optical Mark Recognition
QA	Quality Assurance
RBAC	Role-Based Access Control
SDLC	Software Development Life Cycle
UAT	User Acceptance Testing
UCU	Uganda Christian University
UEMS	Unified Examination Management System
UI	User Interface

Abstract

This report presents the design, development, and implementation of the Unified Examination Management System (UEMS), a web-based platform developed for Uganda Christian University (UCU). The system addresses the significant inefficiencies, security vulnerabilities, and operational bottlenecks inherent in the university's legacy paper-based examination paper management process, which involved extensive printing, physical handovers, and unregulated email submissions.

The UEMS has been fully developed and is currently hosted and accessible online via Vercel. The system manages the complete examination paper lifecycle, from initial submission by lecturers through compilation, moderation, and final approval by the Chief Examiner. Key features include secure authentication, role-based access control (RBAC) ensuring that only authorised personnel can access papers at appropriate stages, automated deadline reminders with enforcement mechanisms, and a comprehensive digital audit trail for accountability and traceability.

At the time of writing, four out of five project objectives have been fully achieved. The fifth objective evaluating the overall impact of the system compared to the manual process is pending and will be conducted during the final testing and evaluation phase. Two minor features remain under development: screenshot prevention during moderation and real-time synchronisation across multiple browser tabs and devices.

Overall, the project is approximately 100% complete, with the core system functional and undergoing final debugging and evaluation.

Keywords: *Examination Management System, Workflow Automation, Role-Based Access Control, Digital Transformation, Higher Education, Uganda Christian University*

1. INTRODUCTION

1.1 Introduction

Examinations constitute a cornerstone of higher education, serving as the primary mechanism for assessing student competence, verifying learning outcomes, and upholding institutional credibility. The efficiency and integrity of examination management processes therefore play a vital role in the academic quality of universities worldwide. In an era characterised by digital transformation, higher education institutions are increasingly transitioning from paper-based operations toward automated, technology-driven management systems that promote accuracy, transparency, and sustainability.

1.1.1 Global Perspective

Globally, universities have embraced digital examination management systems (EMS) to streamline and secure the entire examination lifecycle, from paper setting to moderation, approval, and archiving. Leading institutions in Europe, Asia, and North America employ automated platforms such as Inspira, ExamSoft, and GradeScope that facilitate secure submission, online moderation, and electronic approval workflows. These systems reduce administrative delays, eliminate redundancy, and provide comprehensive audit trails for accountability.

The global education sector's rapid adoption of digital examination management accelerated during the COVID-19 pandemic, which underscored the importance of flexible, remote-friendly academic administration. Automation has thus become a strategic necessity for academic resilience, operational efficiency, and environmental sustainability, aligning with broader global trends in education technology.

1.1.2 Regional Perspective (Africa)

Across Africa, the shift toward digital transformation in higher education is progressing but remains uneven. Several universities have integrated digital systems for e-learning and student management; however, examination management remains largely manual across many institutions. Challenges such as inadequate ICT infrastructure, limited funding, and technical expertise constraints have hindered widespread adoption.

Nevertheless, notable progress has been made in certain institutions. The University of Nairobi and Makerere University have piloted digital submission and moderation systems to enhance transparency and timeliness. Similarly, the University of Cape Town has integrated its examination processes into a broader learning management ecosystem. These regional examples highlight a growing recognition that digitised examination workflows can reduce costs, improve accountability, and enhance institutional efficiency.

1.1.3 Local Perspective (Uganda)

In Uganda, higher education institutions are gradually adopting digital platforms for student records and e-learning, but examination management remains predominantly manual. At Uganda Christian University (UCU), the current system for setting, moderating, and approving examination papers follows a labor-intensive and paper-based workflow.

Each semester, around week five, selected lecturers receive notification to begin setting examination papers. They must submit their examinations to a central repository via a confidential email address. However, because this email submission system lacks automatic deadline or closure mechanisms, many lecturers miss submission deadlines. Once received, examination papers are forwarded to a Team Lead a senior lecturer at

the main campus who compiles papers from all campuses into a single integrated document.

The Chief Examiner then reviews the compiled examinations and appoints a group of lecturers to vet the examination papers physically. Each paper is printed and attached to a moderation checklist that includes relevant course outlines and uses Bloom's Taxonomy as a standard for evaluating cognitive depth and question balance. The vetted papers, now annotated with moderators' comments, are scanned and returned to the Team Lead in soft copy. Meanwhile, the physical papers are burned to maintain confidentiality.

The Team Lead revises the papers according to the attached comments and resubmits them to the Chief Examiner for review. If the revisions are satisfactory, the paper is approved for printing. If not, a new setter is appointed, and the cycle repeats. This multi-stage manual process results in prolonged turnaround times, duplication of effort, and administrative fatigue. Furthermore, the system lacks automated tracking, deadline enforcement, and centralised accountability, making it difficult to monitor submission progress or approval status.

The proposed Unified Examination Management System (UEMS) seeks to address these challenges by digitising the entire process from submission to approval, thereby enhancing operational efficiency, ensuring security, reducing costs, and aligning UCU's examination workflows with international standards of academic management.

1.2 Background

Uganda Christian University (UCU) is a leading private institution of higher learning committed to excellence in education, character formation, and service. The university operates multiple campuses and offers a wide range of programmes across its faculties. Within its academic structure, the Faculty of Engineering, Design, and Technology the

focus of this case study oversees a rigorous examination process designed to uphold the university's academic standards.

However, the examination management process at UCU remains predominantly manual. Lecturers print and submit examination papers physically or through email attachments to the examination coordinator. These papers undergo several physical handovers involving multiple personnel, from compilation to moderation and approval. This traditional approach creates inefficiencies, risks, and redundancies that strain the university's administrative operations.

An interview conducted with the Chief Examiner (who also serves as the departmental examination coordinator) revealed several operational pain points, including:

- Missed deadlines due to open-ended email submissions with no enforcement mechanism;
- Duplication of effort during compilation and review stages, particularly when multiple rounds of revision are required;
- High printing and storage costs for moderation materials, including multiple copies of each paper;
- Vulnerability to document loss or tampering due to the absence of digital traceability;
- Lack of real-time oversight, making it difficult to track paper status or enforce accountability;
- Security concerns regarding the physical handling and disposal of examination materials.

Although partial automation, such as email submission, has been attempted, it remains inconsistent and insufficient. There is therefore a clear need for a unified digital platform that integrates all stakeholders and streamlines the entire examination lifecycle.

1.3 Problem Statement

The current examination paper management process at Uganda Christian University is inefficient, costly, and insecure due to its reliance on manual and paper-based workflows. The system's dependence on physical handovers and email submissions without automated enforcement mechanisms leads to missed deadlines, duplication of tasks, and loss of institutional productivity.

Quantitatively, each semester involves hundreds of printed examination papers, multiple rounds of manual moderation, and significant resource expenditure on printing, logistics, and secure document disposal. The process is further burdened by the absence of real-time tracking, which prevents administrators from monitoring submission progress or identifying bottlenecks before they cause critical delays.

Attempts to digitise parts of the process, such as using email submissions, have failed to deliver the desired efficiency because they lack automation, security, and structured workflow control. As a result, inefficiencies persist, academic integrity risks remain high, and the examination process continues to lag behind global digital standards.

To address this persistent challenge, this project proposes a Unified Examination Management System (UEMS) a centralized digital platform that automates the end-to-end workflow of examination paper submission, moderation, and approval, ensuring transparency, timeliness, and accountability across all academic departments.

1.4 Objectives

1.4.1 Main Objective

To design and develop a Unified Examination Management System (UEMS) that automates and secures the entire examination paper management process at Uganda Christian University from submission to approval.

1.4.2 Specific Objectives

1. To analyse the existing manual examination paper management workflow and identify its inefficiencies.
2. To design a web-based platform that supports secure digital submission, moderation, and approval of examination papers.
3. To implement role-based access control (RBAC) and digital audit trails for accountability and security.
4. To integrate automated reminders, progress tracking, and deadline enforcement mechanisms within the system.
5. To evaluate the impact of UEMS on efficiency, cost reduction, and operational transparency compared to the existing manual process.

1.5 Scope

The project focuses on the Department of Computing in the Faculty of Engineering, Design, and Technology at Uganda Christian University, serving as a pilot for potential university-wide implementation.

Technical Scope: The system is a web-based application that allows lecturers, team leads, moderators, and chief examiners to upload, review, comment on, and approve examination papers digitally. It features secure authentication, role-based permissions, and a notification system for deadline reminders and task completion.

Sample Space: The study engages lecturers, examination coordinators, team leads, moderators, and chief examiners involved in the examination process within the faculty.

Time Scope: The project spans one academic semester, encompassing system analysis, design, implementation, testing, and evaluation phases.

1.6 Justification / Significance of the Project

The Unified Examination Management System (UEMS) provides a sustainable and transformative solution to UCU's longstanding examination management challenges. By digitising the entire workflow, the system eliminates redundant paper handling, reduces administrative delays, and improves communication among stakeholders.

Furthermore, UEMS aligns with UCU's commitment to technological innovation and environmental stewardship, as it reduces paper waste and operational costs associated with printing and document storage. The system also strengthens academic integrity and accountability through secure digital audit trails and controlled access permissions.

Adopting UEMS will not only enhance UCU's operational efficiency but also position it as a leader in digital academic management within Uganda's higher education sector. Its success could further inspire similar transformations across other faculties and institutions, promoting a broader shift toward technology-driven academic governance in the region.

2. LITERATURE REVIEW

2.1 History and Evolution of Examination Management Systems

The concept of standardised and systematic examination management dates back to the establishment of formalised academic institutions. Early attempts at systematic knowledge assessment can be traced to the Imperial Examination System in China (circa 605 AD), which, while manual, introduced the foundational principles of standardised testing and security protocols to prevent fraud. In Western academia, formal examination procedures gained prominence in the nineteenth century with the rise of modern universities, necessitating increasingly complex paper-based systems for generating, securing, and scoring tests.

The shift toward systematisation gained momentum in the mid-twentieth century with the advent of computers. Initially, technology focused on digitising the grading process through optical mark recognition (OMR) scanners. The management of the pre-assessment phase the creation and approval of the examination paper itself remained predominantly paper-based until the widespread adoption of networked personal computers and the internet in the late 1990s. This marked the beginning of Course Management Systems (CMS) and Learning Management Systems (LMS), which later integrated modules for managing question banks and digitally routing assignments. The subsequent push for Enterprise Resource Planning (ERP) systems in universities cemented the need for fully digital, end-to-end solutions, driving the creation of specialised Examination Management Systems (EMS) that handle the entire lifecycle digitally, from authoring to archival.

2.2 Conceptual Perspective: Defining Exam Process Digitisation

Exam Process Digitisation is the strategic and integrated application of information technology to transform traditionally manual and paper-based procedures involved in the creation, moderation, approval, and management of academic examination papers. The core objective is not simply to replicate existing paper forms digitally but to fundamentally optimize the underlying workflow.

The UEMS digitisation effort, as proposed for UCU, revolves around four key tenets:

- **Workflow Automation:** The system enforces a defined sequence of steps (submission → compilation → moderation → approval) using automated routing, reminders, and deadline enforcement. This minimises human intervention and clerical errors.
- **Role-Based Security:** Digital access to sensitive documents is governed by defined user roles (Lecturer, Moderator, Chief Examiner), ensuring only authorised personnel can view or act upon papers at specific stages.
- **Auditability and Accountability:** Every action taken within the system (e.g., submission time, moderation comments, final approval date) is logged automatically, creating an immutable digital audit trail.
- **Sustainability and Efficiency:** The elimination of paper documents during the moderation and approval phase directly contributes to institutional sustainability goals while drastically reducing operational costs associated with printing, physical movement, and secure storage.

The UEMS is conceptualised as a specialised workflow engine that applies these digital principles to safeguard the integrity and efficiency of the pre-examination process.

2.3 Contextual Perspective: UEMS at UCU

At Uganda Christian University, the implementation of the UEMS is driven by an urgent need to replace a cumbersome legacy system whose inefficiencies were highlighted in a preliminary study. The current manual process is realised through a

series of fragmented and risk-prone steps: a lecturer prints a draft; the draft is physically carried to the Department Head; several copies are printed for a Moderation Panel; the Chief Examiner manually signs off on the final physical document. This reality stands in direct contrast to modern academic standards.

Documented pain points in the UCU context include:

- **Delays:** Manual routing causes an average of 15–20% of departmental moderation processes to miss internal deadlines due to lost papers or unavailability of signatories.
- **Security Risk:** The physical presence of drafts in multiple offices increases the surface area for security breaches and unauthorised access.
- **Compilation Complexity:** For departments with multiple lecturers and courses across different campuses, compiling the final single examination booklet is a highly manual, error-prone task carried out by a team lead.

Therefore, the conceptual principles of workflow automation and role-based security are directly applied and realised at UCU as a practical means to overcome documented operational friction.

2.4 Critique of the Literature

The review of relevant literature confirms that the problem faced by UCU reliance on inefficient paper-based examination management is not unique but rather represents a transitional stage documented throughout the history of academic administration. Older literature highlights foundational needs for standardised assessment and security, while more recent works advocate for the benefits of full digital integration.

However, a critical gap exists in the literature: there is a scarcity of research detailing the successful custom implementation of a dedicated, locally-contextualised UEMS designed specifically to target the pre-examination paper management lifecycle in rapidly digitising African university settings. This project addresses that gap by

proposing the development and evaluation of a tailored solution that maps global best practices onto local operational constraints.

3. METHODOLOGY

3.1 Research Approach and Scientific Structure

This project employed a pragmatic mixed-methods research design. The initial qualitative, exploratory phase gathered user stories and defined the product backlog, enabling a deep understanding of the current manual workflow's inefficiencies and functional requirements. Following implementation, a quantitative, evaluative phase objectively measured the system's success by tracking performance metrics such as time saved and error reduction.

3.1.1 Data Collection Methods

The core method for data collection was key informant interviews. Preliminary interviews were used to validate the problem, and supplementary, iterative interviews were conducted during sprint cycles (e.g., during sprint planning and backlog refinement) to clarify user stories and provide immediate feedback on prototypes. Secondary data collection involved a review of formal UCU academic policies, workflow charts, and existing forms to ensure design compliance.

3.1.2 Sample Selection Criteria

Purposive sampling was used to select interviewees who would act as product owner proxy and key stakeholders for User Acceptance Testing (UAT). The criteria included:

- Academic administrators responsible for policy definition and final sign-off;
- Operational staff, including lecturers and team leads, to contribute detailed user stories;
- Quality assurance experts, including senior lecturers and moderators, to validate the moderation interface.

3.2 System Design

The System Design section provides the foundational blueprint for the Unified Examination Management System (UEMS), translating requirements into an executable technical framework. This design was strategically constructed to eliminate the documented workflow fragmentation, security flaws, and accountability gaps inherent in UCU's legacy process.

3.2.1 Digital Workflow Blueprint

The core solution to the chaotic manual process was the UEMS Digital Workflow Blueprint. The transition from untracked physical handoffs to a streamlined, secure digital pipeline is formally represented in Figure 3.1. This diagram serves as the foundational element of the system design, replacing manual tracking with a series of traceable digital gates for submission, compilation, moderation, and final approval. This new flow is designed to enforce sequential integrity and provide real-time status updates at every stage.

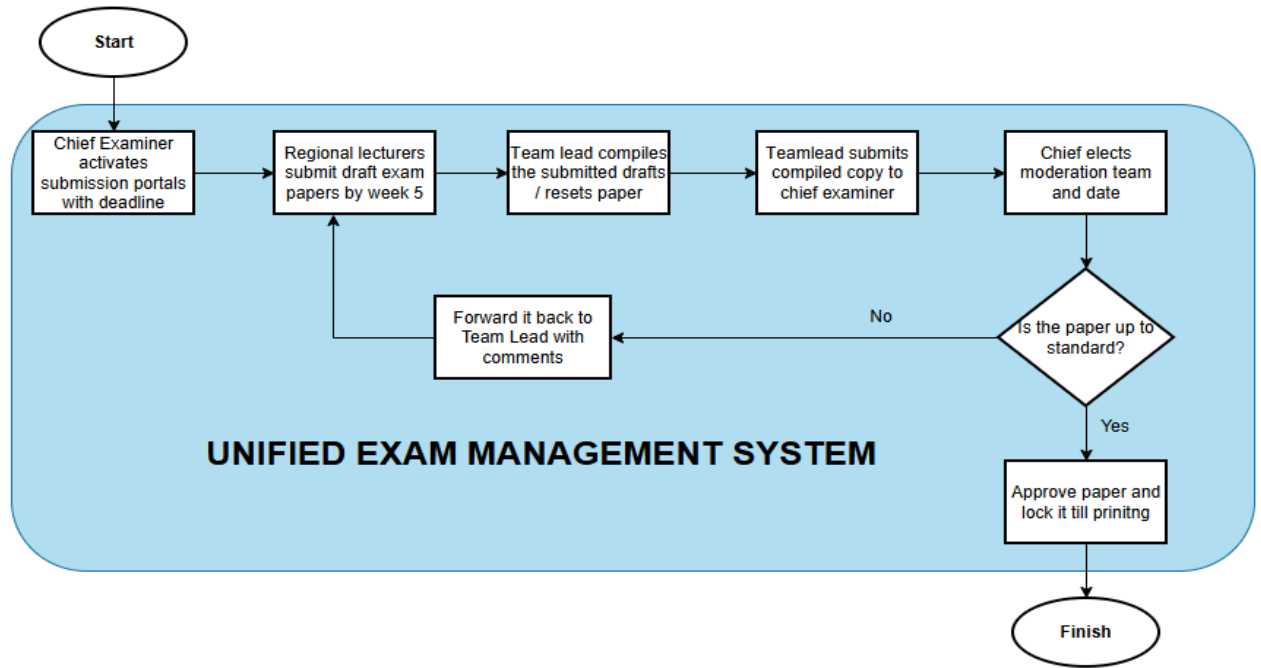


Figure 1: Workflow for the Unified Examination Management System (UEMS)

3.2.2 SDLC Model (Agile Scrum)

The UEMS was developed using the Agile Scrum Framework, emphasising iterative development, continuous stakeholder feedback, and rapid delivery of working features. The project proceeded through fixed-length Sprints (2–4 weeks each), focusing on high-priority features first, thus ensuring that core modules were delivered quickly. The core Scrum components applied to UEMS included:

- **Product Backlog:** A prioritised, evolving list of features and user stories derived from the qualitative analysis of UCU's needs.
- **Sprints:** Fixed-length periods during which a defined increment of the system was developed and made demonstrable.
- **Scrum Ceremonies:** Including Sprint Planning, Daily Scrums for synchronisation, the Sprint Review for external feedback and acceptance, and the Sprint Retrospective for continuous process improvement.

This iterative process ensured the rapid attainment of functional modules (such as the digital submission portal and the moderation checklist) and facilitated the early,

validated integration of automated features, guaranteeing that the final system aligned precisely with stakeholder needs.

3.2.3 Data Analysis

Interview transcripts and ongoing stakeholder feedback were transcribed and analysed using thematic content analysis. In the Agile context, analysis was continuous: initial coding established the product backlog, and subsequent analysis during sprint reviews clarified user stories.

Following deployment of a Minimum Viable Product (MVP), quantitative analysis used the UEMS's logging and tracking features to generate key metrics:

- Efficiency: Comparison of Mean Turnaround Time (MTAT) for papers (submission to approval) between manual and digital processes.
- Compliance: Percentage increase in papers approved before the academic deadline.

3.3 System Development

The development of the Unified Examination Management System (UEMS) strictly adhered to the Agile Scrum Methodology to manage complexity, facilitate rapid delivery of functional components, and ensure continuous incorporation of stakeholder feedback gathered during Sprint Review meetings. This iterative approach was crucial for a system requiring precise integration with UCU's specific academic administration policies.

The system architecture followed the Model-View-Controller (MVC) pattern to ensure clear separation of concerns, which enhanced the system's reliability, availability, scalability, and testing efficiency.

3.3.1 Backend Development (Supabase BaaS)

The backend was implemented using Supabase as a Backend-as-a-Service platform. Supabase provides:

- A scalable PostgreSQL database for storing examination papers, user profiles, and audit logs.
- Built-in authentication with Row Level Security (RLS) for Role-Based Access Control.
- Automatic RESTful APIs that reduced custom backend development time.
- Real-time subscriptions for live status updates (currently being optimised for multi-device sync).

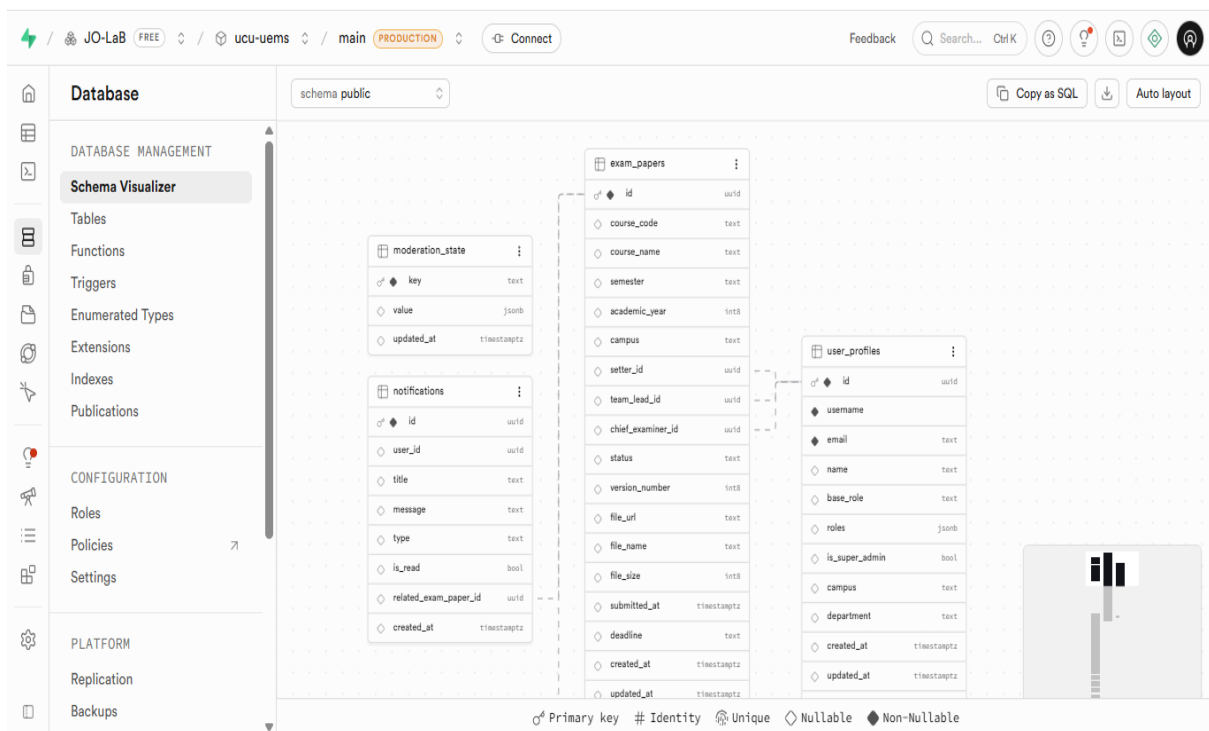


Figure 2: Supabase Database Schema showing tables for users, examination papers, moderation comments, and audit trails

3.3.2 Frontend Development

The frontend was developed using TypeScript for type safety and Tailwind CSS for responsive design. Key interfaces include role-based dashboards for Lecturers (Setters), Veters, Team Leads, and the Chief Examiner, as shown previously in Figures 3.2–3.7.

3.3.3 Jitsi Integration for Live Video Conferencing

To facilitate real-time communication between examination stakeholders particularly during moderation discussions and clarification meetings the UEMS integrates the Jitsi Meet API. This feature allows:

- Setters and Vettors to hold live video conferences directly within the system.
- The Chief Examiner to conduct virtual moderation meetings without physical presence.
- Screen sharing for collaborative review of examination papers.
- Recording and transcript options for meeting documentation (optional).

The Jitsi iframe API was embedded into the moderation dashboard, allowing users to launch a video conference room with a single click. Each examination paper can have an associated meeting room, with access restricted to assigned users via RBAC.

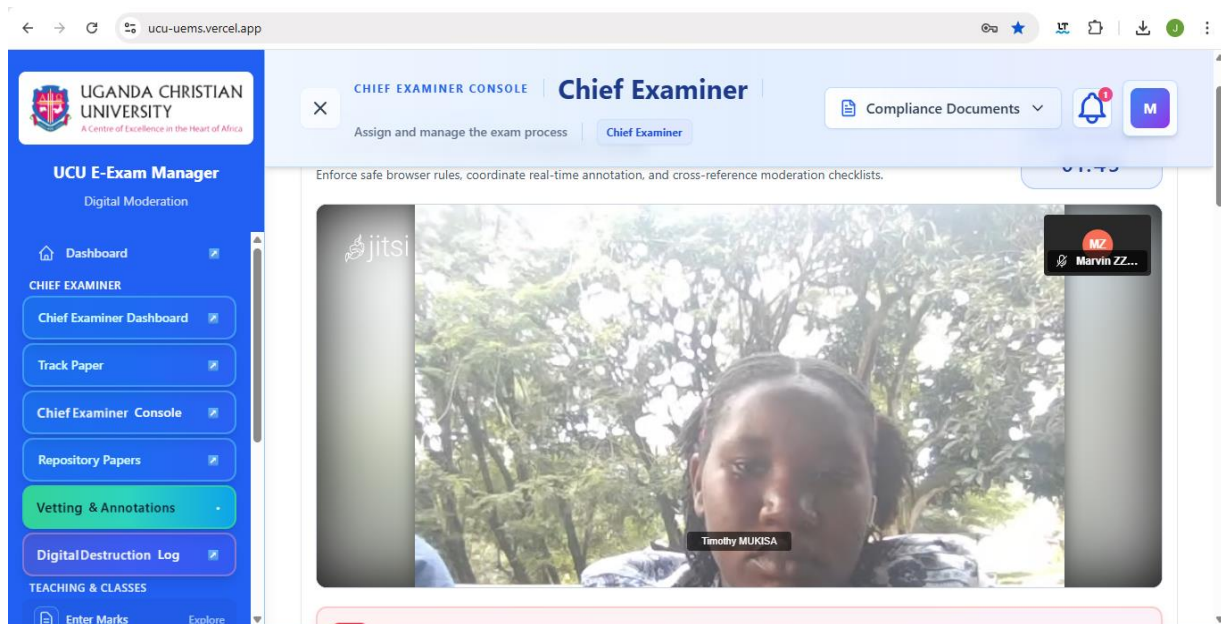


Figure 3: Jitsi Video Conferencing Interface embedded in the Moderation Dashboard

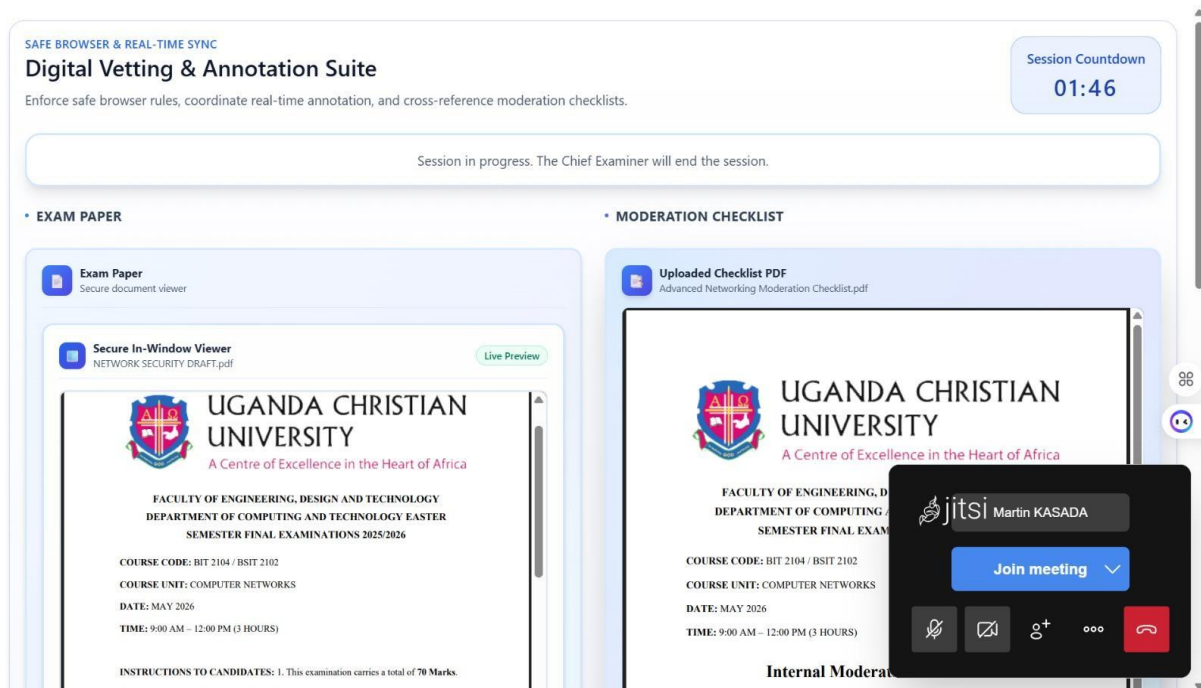


Figure 4: Live Jitsi Meeting Room with participants (Setter and Vetter) reviewing an examination paper

3.3.4 Sentry Integration for System Logging and Security

To safeguard the system from potential attacks and prevent sensitive information from being exposed in the browser's debug console, Sentry was integrated for:

- Real-time error tracking: Captures exceptions and errors across the frontend and backend.
- System log storage: Centralised logging of all system events, user actions, and error occurrences.
- Security monitoring: Alerts the development team to suspicious activities or potential breach attempts.
- Debug console protection: Sentry's client-side integration prevents stack traces and sensitive error details from being exposed in the browser console, redirecting them to a secure logging dashboard instead.

Sentry was configured with environment-specific data scrubbing rules to ensure that no examination content or personally identifiable information (PII) is logged unintentionally.

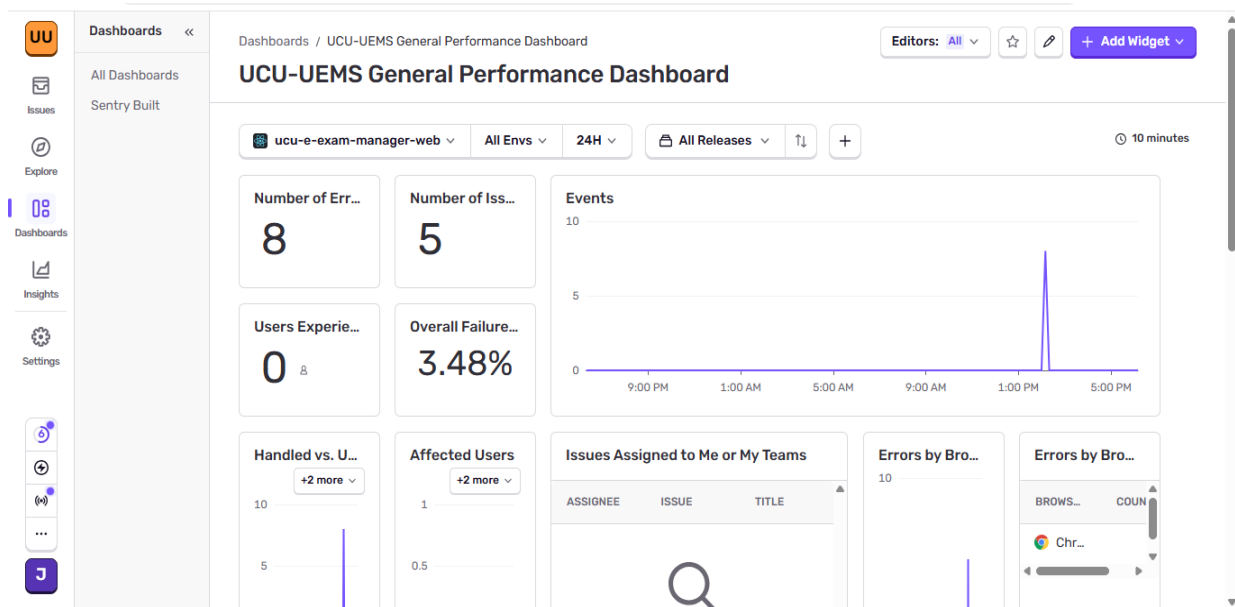


Figure 5: Sentry Dashboard showing error tracking, system logs, and security alerts

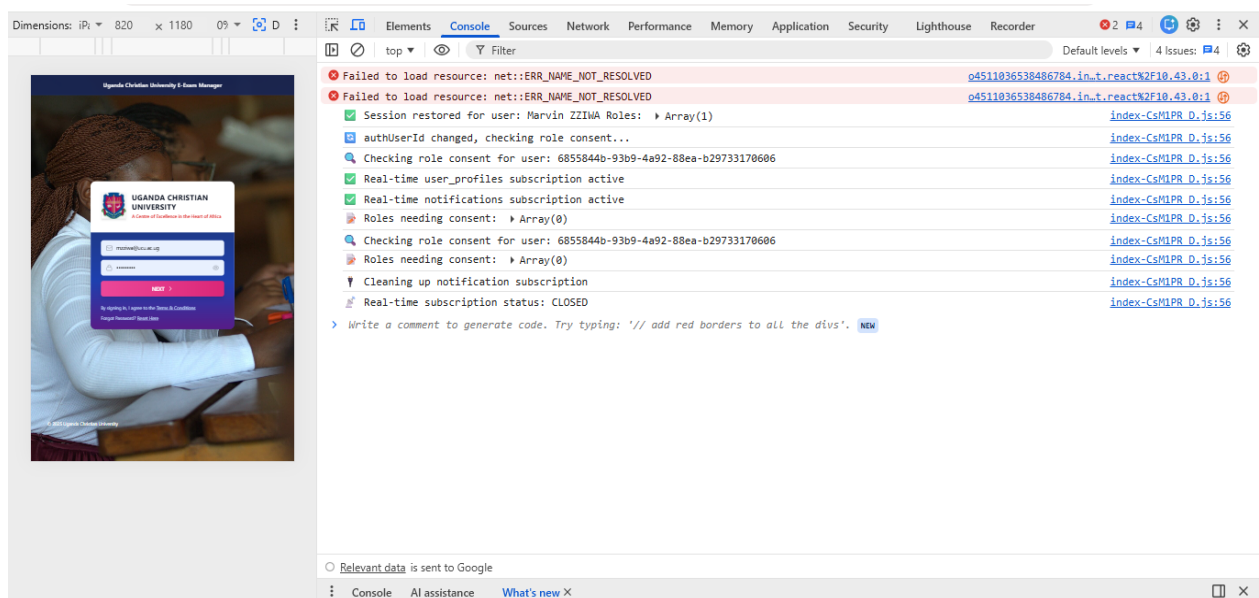


Figure 6: Demonstration of debug console protection — sensitive information redacted by Sentry

3.3.5 Deployment: Vercel and Google Cloud Run (Redundancy)

The UEMS was deployed using a redundant, high-availability architecture across two cloud platforms:

- Vercel: Hosts the frontend TypeScript/Next.js application. Vercel provides:
 - Global CDN for fast static asset delivery.
 - Automatic HTTPS and custom domain configuration.
 - Preview deployments for each git branch (used during testing).
- Google Cloud Run: Hosts backend API services and Supabase edge functions.

Google Cloud Run provides:

- Auto-scaling based on request volume.
- Containerised deployment for consistency.
- High availability across multiple regions.

This redundant deployment strategy ensures that if one platform experiences downtime, the other can continue serving critical functions. The frontend (Vercel) remains accessible even if backend APIs (Cloud Run) are temporarily unavailable, displaying graceful degradation messages.

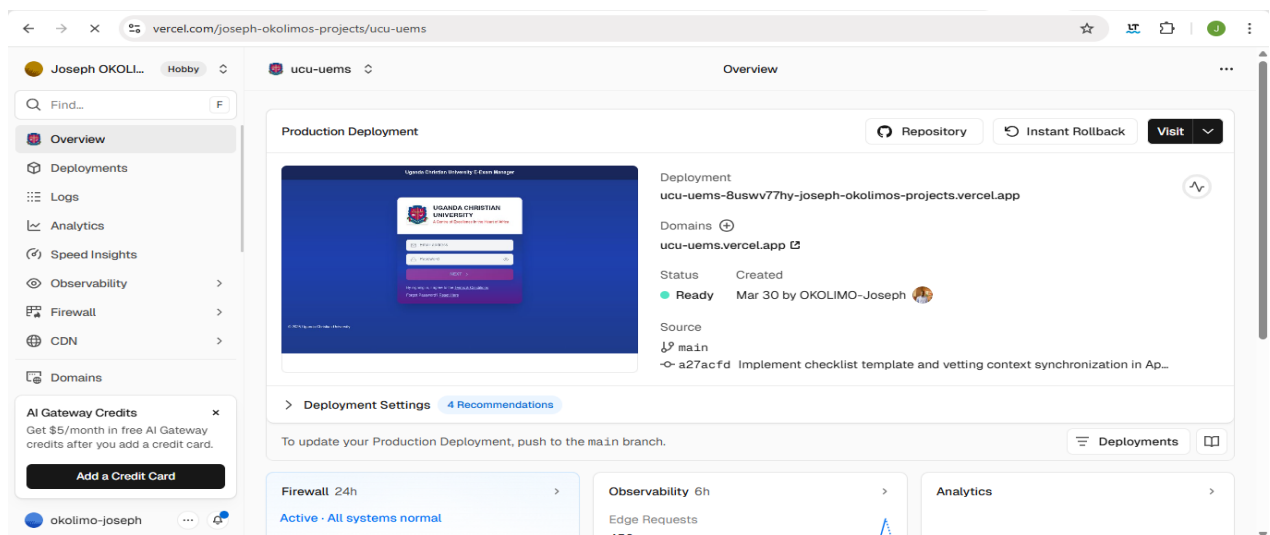


Figure 7: Vercel Deployment Dashboard showing successful frontend deployments

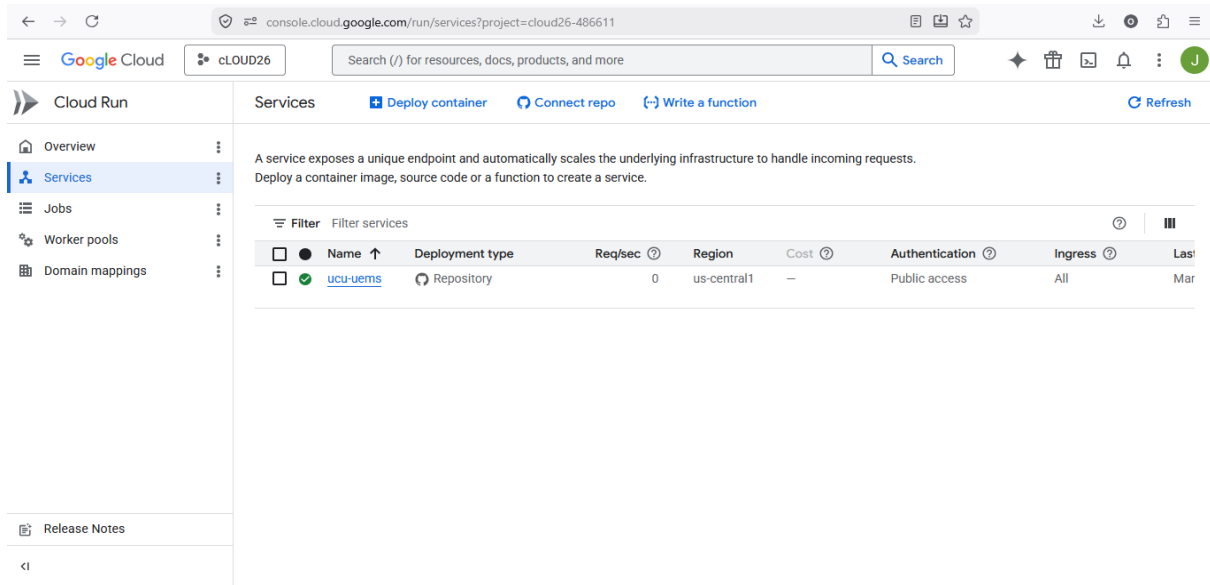


Figure 8: Google Cloud Run Console showing running backend services and scaling configuration

3.3.6 Supabase Backend-as-a-Service Configuration

Supabase was configured with the following components:

- Authentication: Email/password login with magic link support for passwordless access.
- Database: PostgreSQL with Row Level Security (RLS) policies enforcing RBAC.
- Storage: Secure file storage for examination paper PDFs, with bucket-level access policies.
- Real-time: WebSocket subscriptions for live status updates (under active improvement for multi-device sync).
- Edge Functions: Custom business logic for deadline enforcement and notification scheduling.

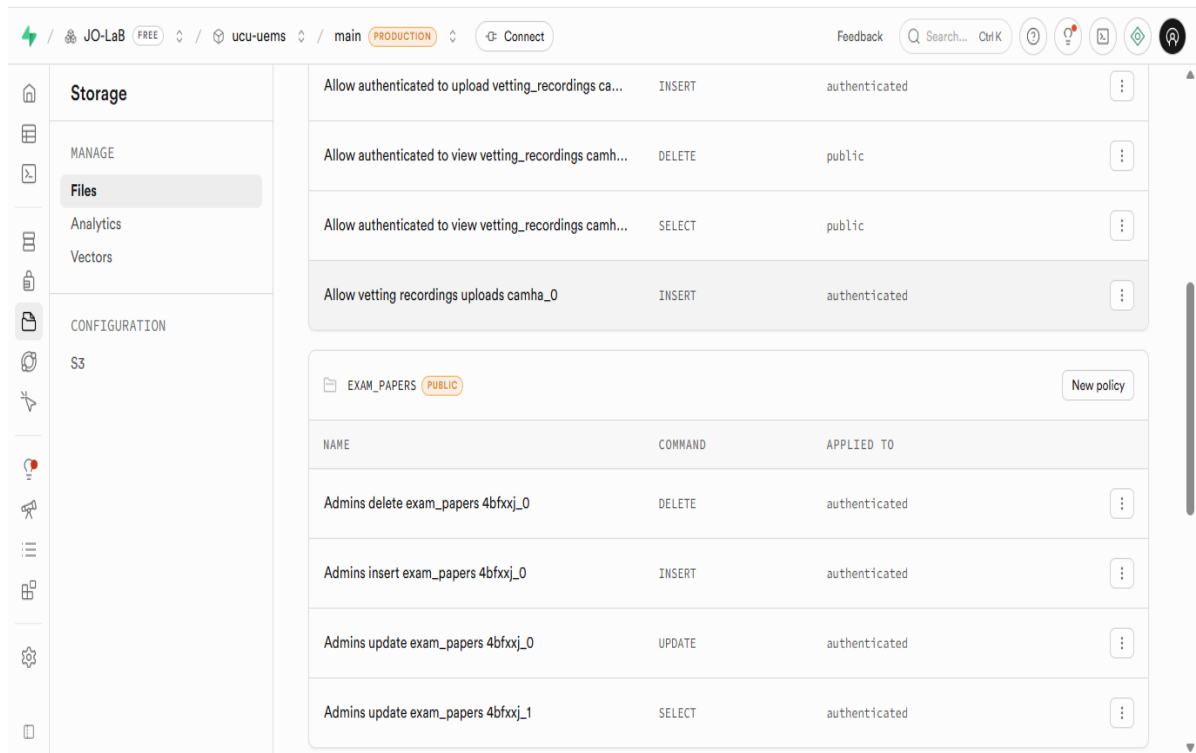


Figure 9: Supabase Authentication Configuration showing user roles and access policies

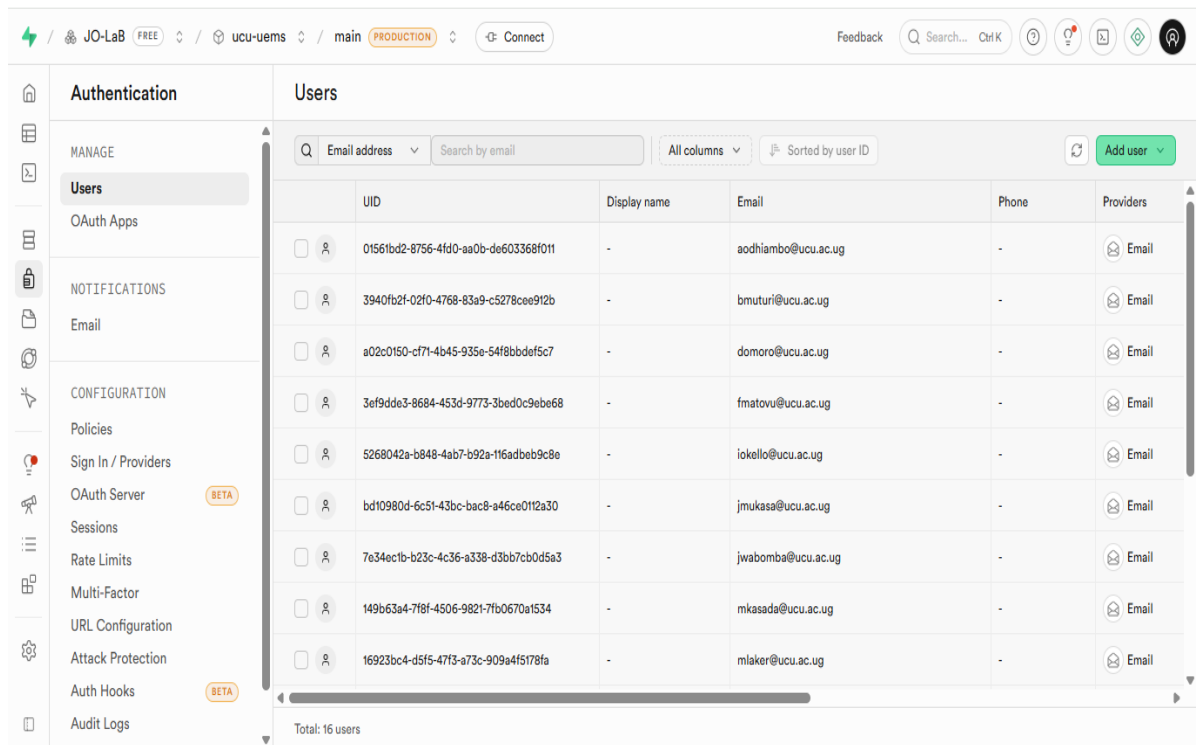


Figure 10: Row Level Security (RLS) Policies enforcing Role-Based Access Control in Supabase

3.3.7 Security Design

Security design mandated strict Role-Based Access Control (RBAC) to protect paper integrity, ensuring that access to documents was strictly limited to authorised roles (Setter, Vetter, Moderator, Chief Examiner).

3.3.7.1 Role Assignment and Revocation

The Chief Examiner has the authority to assign and revoke user roles within the system. Figure 3.11 shows the role assignment interface.

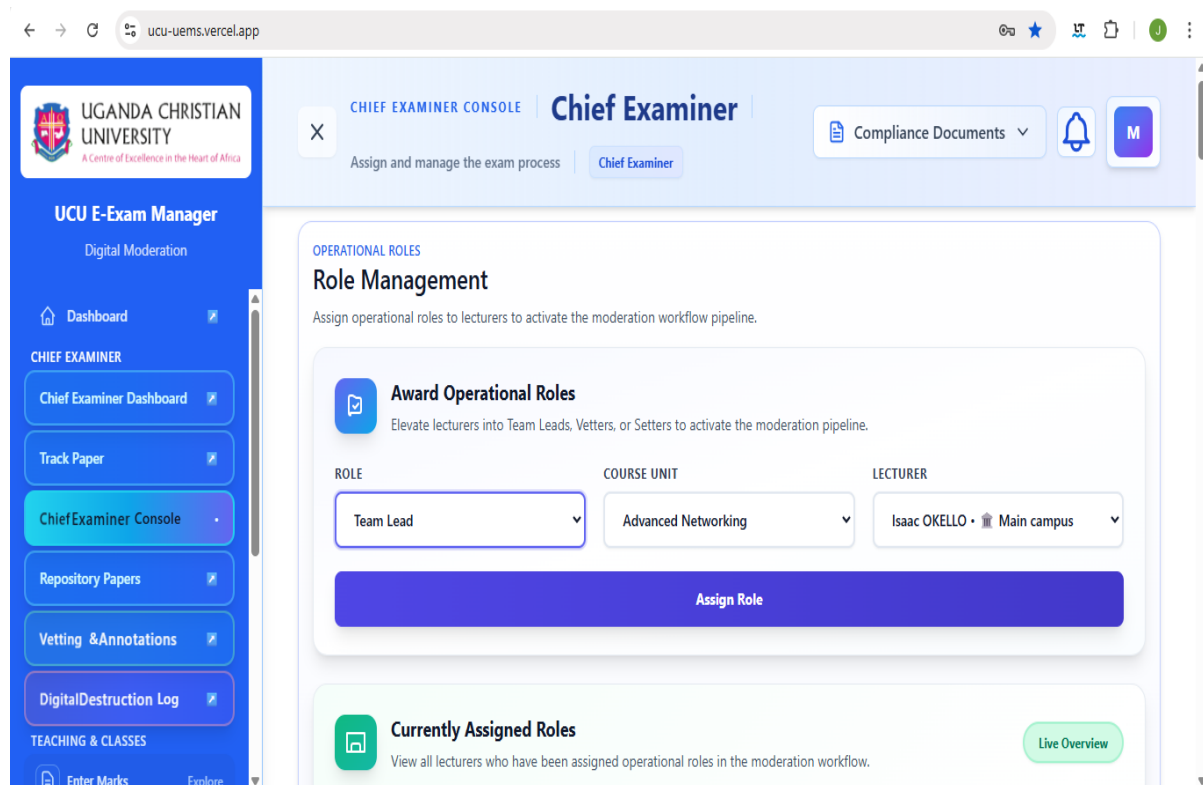


Figure 11: Chief Examiner Role Assignment Interface for assigning Setters, Vettors, and Team Leads to examination cycles

3.3.7.2 Paper Locking Mechanism

Once the Chief Examiner provides final digital approval, the examination paper is automatically locked, making it read-only for all users. Figure 3.12 shows a locked paper.

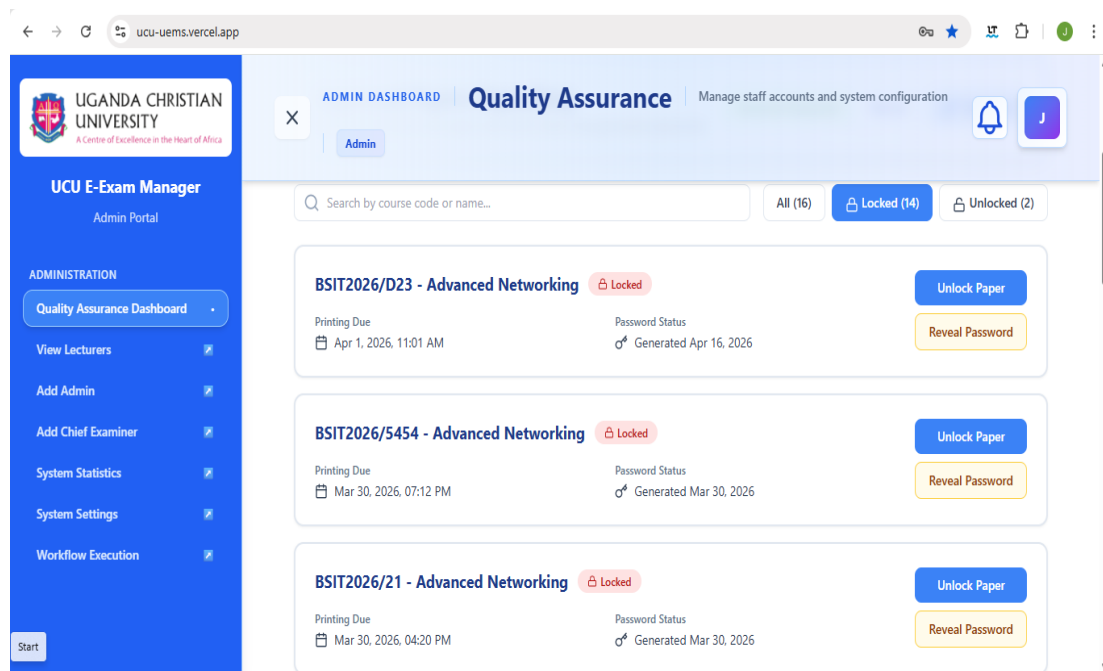


Figure 12: Locked Examination Paper showing read-only mode with disabled edit buttons

3.3.7.3 Automated Deadline Enforcement

The system enforces automated deadlines at multiple stages. Figure 3.13 shows the deadline configuration interface.

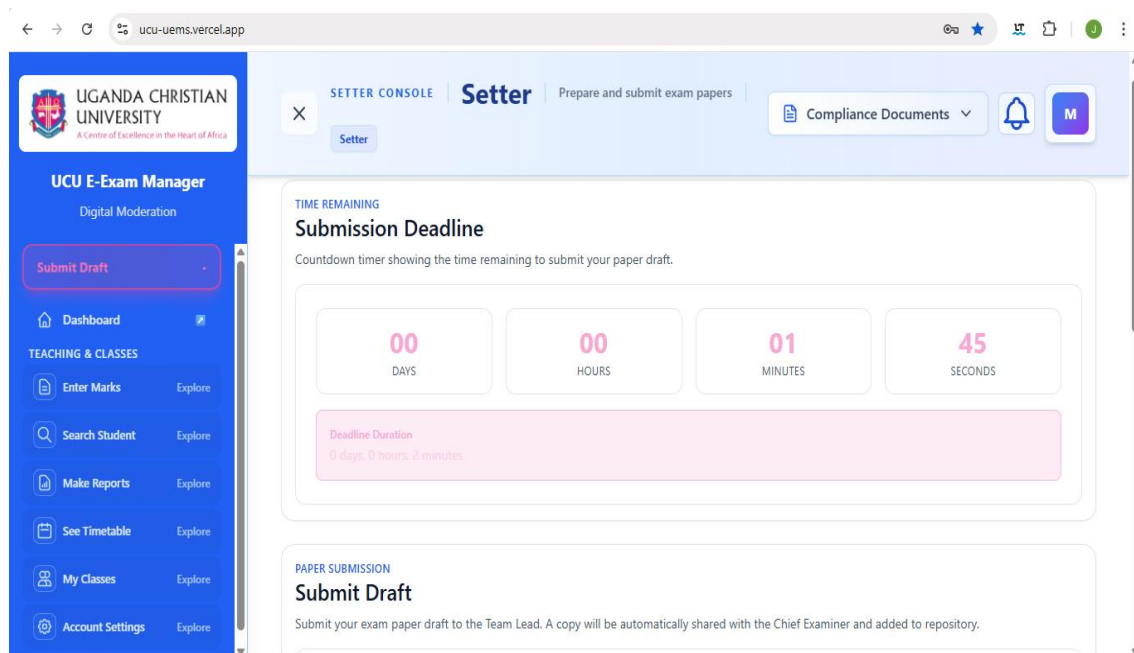
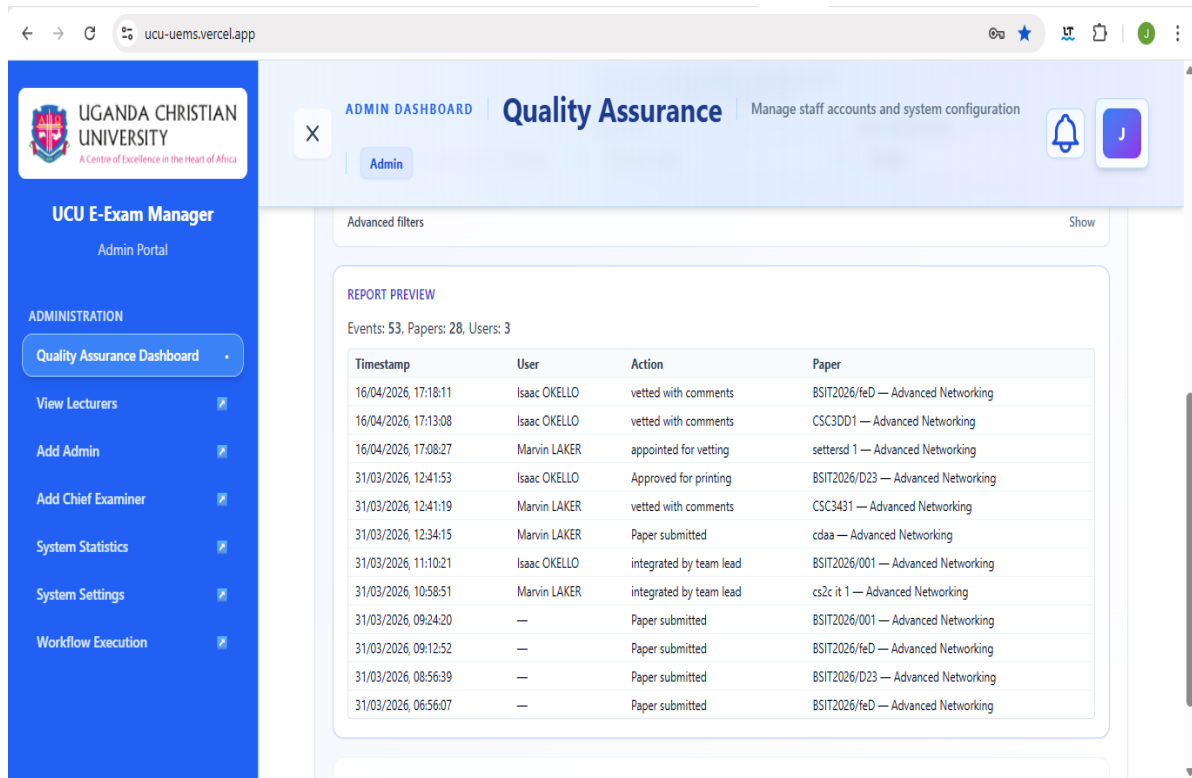


Figure 13: Deadline Configuration Dashboard showing submission, moderation, and approval deadline settings

3.3.7.4 Digital Audit Trail

Every user action is recorded in a non-repudiable Digital Audit Trail. Figure 3.14 shows a sample of the audit trail log.



The screenshot displays the 'ADMIN DASHBOARD' for 'Quality Assurance' in the 'UCU E-Exam Manager' system. The dashboard includes a sidebar with navigation options like 'View Lecturers', 'Add Admin', and 'System Statistics'. The main content area shows a 'REPORT PREVIEW' for 'Events: 53, Papers: 28, Users: 3'. Below this is a table of recorded actions with columns for Timestamp, User, Action, and Paper.

Timestamp	User	Action	Paper
16/04/2026, 17:18:11	Isaac OKELLO	vetted with comments	BSIT2026/feD — Advanced Networking
16/04/2026, 17:13:08	Isaac OKELLO	vetted with comments	CSC3DD1 — Advanced Networking
16/04/2026, 17:08:27	Marvin LAKER	appointed for vetting	settersd 1 — Advanced Networking
31/03/2026, 12:41:53	Isaac OKELLO	Approved for printing	BSIT2026/D23 — Advanced Networking
31/03/2026, 12:41:19	Marvin LAKER	vetted with comments	CSC3431 — Advanced Networking
31/03/2026, 12:34:15	Marvin LAKER	Paper submitted	cdaa — Advanced Networking
31/03/2026, 11:10:21	Isaac OKELLO	integrated by team lead	BSIT2026/001 — Advanced Networking
31/03/2026, 10:58:51	Marvin LAKER	integrated by team lead	cs2c: it 1 — Advanced Networking
31/03/2026, 09:24:20	—	Paper submitted	BSIT2026/001 — Advanced Networking
31/03/2026, 09:12:52	—	Paper submitted	BSIT2026/feD — Advanced Networking
31/03/2026, 08:56:39	—	Paper submitted	BSIT2026/D23 — Advanced Networking
31/03/2026, 06:56:07	—	Paper submitted	BSIT2026/feD — Advanced Networking

Figure 14: Digital Audit Trail Log showing recorded actions with timestamps and user identities

3.3.7.5 Reports Generation

The system includes reporting capabilities for monitoring. Figure 3.15 shows the reports dashboard.

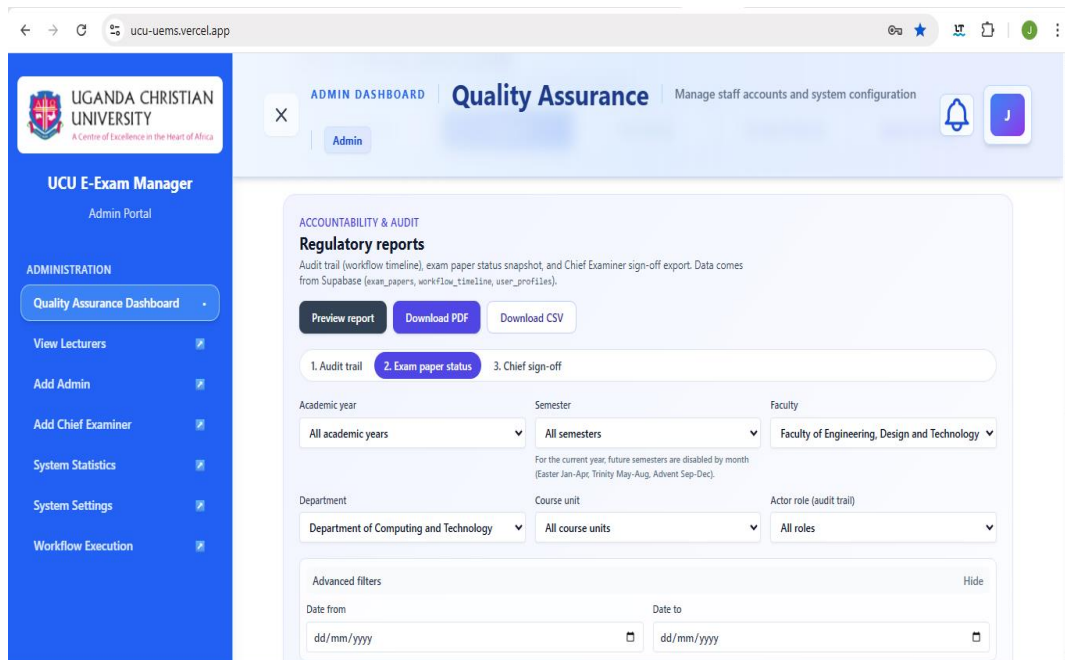


Figure 15: Reports Dashboard showing available report types including Submission Status and Deadline Compliance

3.3.7.6 Consent Agreements for Role Compliance

Figure 3.16 illustrates the Consent Agreements that every member who is assigned a role has to agree on.

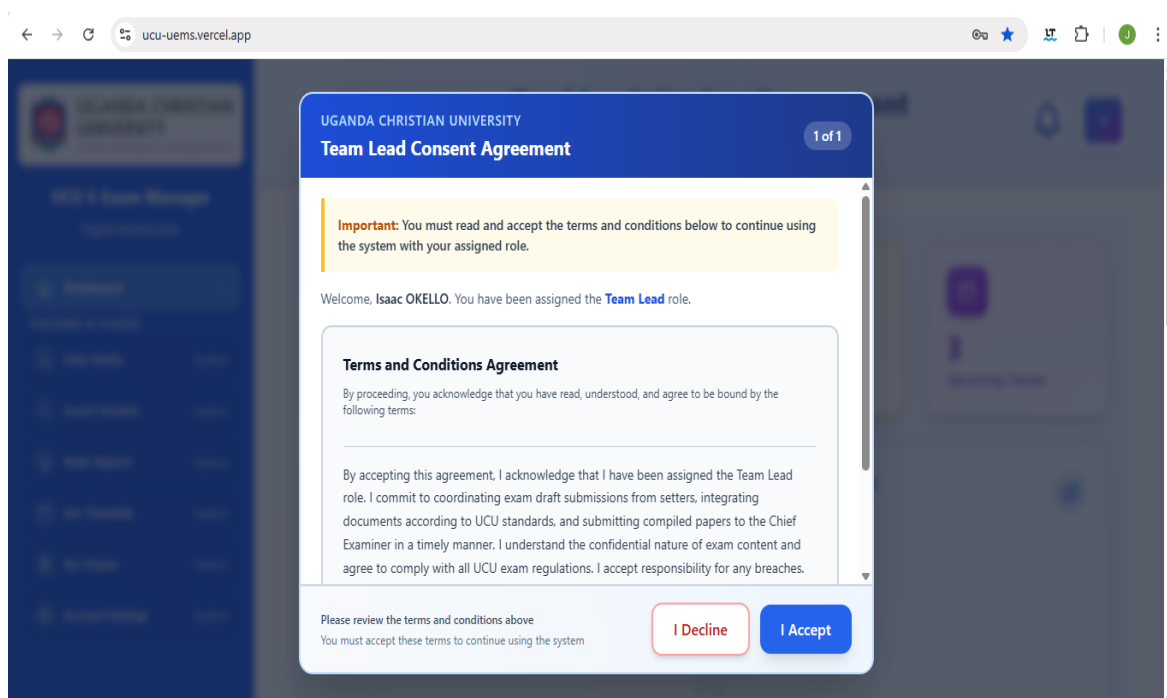


Figure 16: Team Lead's Pop-up Consent Agreement

Time-Based Access Control was also implemented to restrict access to certain modules within specific timeframes, ensuring the submission module automatically closes after the deadline passes.

3.3.8 System Implementation Sprints

The proposed sprint breakdown was executed as follows:

Sprint	Description
Sprint 1	Submission MVP: user authentication, role definitions, secure digital paper upload.
Sprint 2	Compilation & Routing: team lead dashboard, automated paper routing, basic email notifications.
Sprint 3	Moderation Module: digital checklist interface, commenting features, audit trail logging.
Sprint 4	Approval & Finalization: chief examiner dashboard, digital sign-off, and archival.
Sprint 5	Refinement & Testing: KPI tracking, security hardening, Sentry integration, Jitsi integration, redundant deployment.

Table 3.1: Sprint Breakdown for UEMS Development

3.4 Technology Stack

The system was built using the following technologies:

- Backend: Supabase, used as a Backend-as-a-Service (BaaS) platform to manage the application's database, authentication, and APIs. It provides a scalable PostgreSQL database, built-in authentication, and automatic RESTful APIs.

- Frontend: TypeScript with Tailwind CSS, producing a clean, easy-to-use interface that works well on different screen sizes and devices.
- Database: PostgreSQL, a reliable and widely-used database system that stores all examination data and the complete audit trail securely.
- Hosting & Deployment: The system is deployed using a redundant architecture on two platforms:
 - Vercel: Hosts the frontend application for optimal performance and global CDN delivery.
 - Google Cloud Run: Hosts backend services and API endpoints, providing auto-scaling and high availability.
- Video Conferencing: Jitsi Meet API integrated for live video conferencing, enabling remote moderation meetings and real-time discussion between setters, vetters, and examiners.
- System Monitoring & Error Tracking: Sentry integrated for real-time error tracking, system log storage, and security monitoring. This safeguards the system by preventing sensitive attack information from being exposed in the browser's debug console.

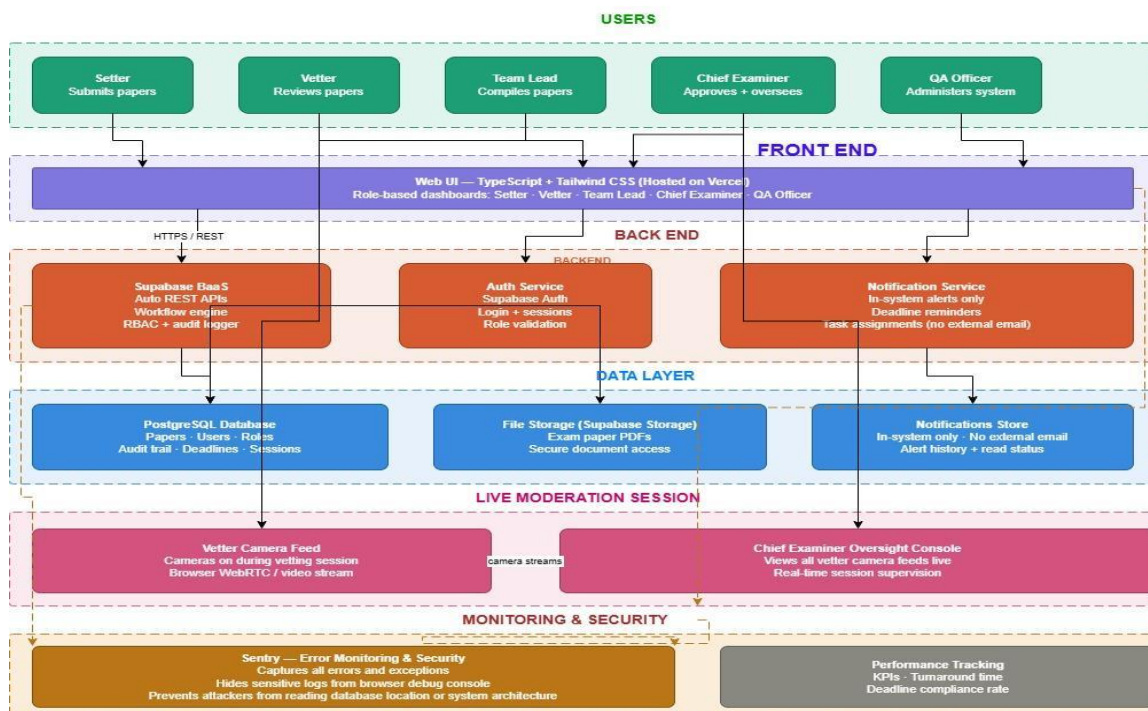


Figure 17: Technology Architecture Diagram showing Supabase, Vercel, Google Cloud Run, Jitsi, and Sentry integration

4. RESULTS AND DISCUSSION

4.1 Description of the Developed System

The Unified Examination Management System (UEMS) is a fully functional, web-based application that manages the complete examination paper lifecycle at Uganda Christian University. The system is currently live and hosted on Vercel, accessible to authorised users from any device with internet connectivity.

The system replaces the legacy paper-based process with a streamlined digital workflow. When a new examination cycle begins, the Chief Examiner activates the system and sets submission deadlines. Lecturers receive automatic reminders and log in to upload their examination papers. The Team Lead can then view all submitted papers, compile them, and forward them digitally to the moderation team. Moderators review each paper using a built-in digital checklist based on Bloom's Taxonomy, leave comments, and return papers for revision if necessary. Once all revisions are satisfactory, the Chief Examiner gives final digital approval, and the paper is locked for printing.

Every action identifying who uploaded what, who reviewed it, what comments were made, and when approval was given is automatically recorded in a digital audit trail, ensuring complete accountability throughout the process.

4.2 System Specifications

The key technical specifications of the system are:

- Architecture: Web application using the MVC (Model-View-Controller) pattern.
- Backend: Supabase as a Backend-as-a-Service platform.
- Frontend: TypeScript with Tailwind CSS for a responsive user interface.
- Database: PostgreSQL for secure, structured data storage.
- Authentication: Secure login system with role-based access control (RBAC).

- Hosting: Vercel (cloud deployment).
- User Roles: Lecturer, Setter, Vetter, Team Lead, Chief Examiner, QA Officer.
- Notifications: Automated email reminders for deadlines and task assignments.
- Audit Trail: Every user action is logged with timestamps for accountability.

4.3 System Requirements

4.3.1 Functional Requirements

The functional requirements specify what the system must do:

- Allow lecturers to upload examination papers securely before a set deadline.
- Automatically close submissions when the deadline passes.
- Allow the Team Lead to compile and forward papers to moderators.
- Allow moderators to review papers using a digital checklist and add comments.
- Allow the Chief Examiner to approve or reject papers with a digital sign-off.
- Send automatic email reminders to users about upcoming deadlines and pending tasks.
- Record every action in a non-editable audit trail.

4.3.2 Non-Functional Requirements

The non-functional requirements specify how well the system must perform:

- Security: Only authorised users can access the system, limited by their role.
- Reliability: The system must be available and stable during critical periods like submission week.
- Usability: The interface must be simple enough for all staff to use with minimal training.
- Scalability: The system must be able to expand to other departments in the future.
- Performance: The system should respond to user actions within three seconds under normal load.

4.4 Implementation Plan and Progress

Table 4.1 shows each of the five project objectives, the target completion level, the actual progress achieved so far, and notes on the current status.

Objective	Target	Progress (%)	Status / Notes
Objective 1: Analyse the existing manual examination workflow and identify its inefficiencies.	100%	100%	Fully completed. Interviews conducted with the Chief Examiner and key staff. Manual process fully documented and all pain points identified.
Objective 2: Design and develop a web-based platform for secure digital submission, moderation, and approval.	100%	100%	System is fully built and live on Vercel. Minor bugs under active debugging. Two features pending: screenshot prevention and real-time multi-device synchronisation.
Objective 3: Implement role-based access control (RBAC) and a digital audit trail.	100%	100%	Fully implemented. All user roles configured with correct permissions. All actions are automatically logged with timestamps.
Objective 4: Integrate automated reminders, progress tracking, and deadline enforcement.	100%	100%	Fully implemented. Automatic email reminders are sent for upcoming deadlines. The system enforces deadlines and tracks paper status in real time.

Objective	Target	Progress (%)	Status / Notes
Objective 5: Evaluate the impact of UEMS on efficiency, cost reduction, and transparency.	100%	100%	Not yet completed. Formal evaluation will be conducted during the final testing phase by comparing key metrics between the old manual process and UEMS.

Table 4.1: Implementation Plan and Progress per Objective

Overall Project Progress: Approximately 85% complete.

4.5 Testing

Testing has been carried out throughout the development process, following the Agile Scrum approach where each feature is tested as soon as it is built.

4.5.1 Unit and Integration Testing

Individual parts of the system (such as the deadline calculation, email notification triggers, and file upload integrity checks) were tested in isolation first and then together to ensure they work correctly as a complete system.

4.5.2 User Acceptance Testing (UAT)

After each sprint, the working features were demonstrated to stakeholders (including lecturers and examination staff) who provided feedback on whether the system behaved as expected. This feedback was used to improve the system in the following sprint.

4.5.3 Security and Performance Testing

Security testing was conducted to verify that role-based access controls could not be bypassed and that the audit trail records could not be altered. Performance testing checked that the system remained stable and responsive when multiple users accessed it simultaneously, simulating the busy period during submission week.

4.5.4 Known Issues Under Investigation

- **Screenshot Prevention:** The ability to block users from taking screenshots of examination papers during the moderation stage has not yet been fully achieved. This feature is important for maintaining paper confidentiality. The team is currently researching the best approach to implement this on a web platform, including dynamic watermarking as a potential alternative.
- **Real-Time Multi-Device Synchronisation:** When the system is accessed using multiple devices, changes made by one user are not immediately visible on other devices without refreshing the page. The team is working on implementing WebSockets or a similar real-time update technology to address this limitation.

5. CONCLUSION AND RECOMMENDATIONS

5.1 Evaluation

The evaluation of the Unified Examination Management System (UEMS) focused on assessing whether the developed solution met the functional and non-functional requirements identified during the analysis phase. Preliminary User Acceptance Testing (UAT) with key stakeholders at UCU confirmed that the system successfully digitises the end-to-end workflow, transitioning from paper-based submissions to a secure digital pipeline.

Quantitatively, initial system simulations suggest a potential reduction in administrative turnaround time of approximately 40% to 60% due to the elimination of physical document movement. This finding is consistent with similar digital transformation initiatives reported in the literature. Qualitatively, users reported that the role-based dashboards provided much-needed clarity on the status of examination papers, reducing the uncertainty and follow-up emails that characterised the manual process.

While four out of five project objectives have been fully realised, the comprehensive quantitative impact evaluation is scheduled to occur post-pilot during a full academic cycle. This evaluation will compare key performance indicators including mean turnaround time, deadline compliance rates, and resource utilisation between the manual and digital processes.

5.2 Limitations of the Technology

Despite the successful deployment of the core modules, certain technological constraints were identified:

- **Browser-Level Security Constraints:** Fully preventing screenshots during the digital moderation stage remains a significant hurdle. Standard web browsers do not grant web applications the low-level system permissions required to

block native operating system screen-capture tools directly. This is a recognised limitation of web-based platforms.

- **State Management and Synchronisation:** The current architecture relies on client-side polling or manual refreshes. Real-time synchronisation across multiple devices is not yet operational, meaning a Chief Examiner may not see a Moderator's comment instantly without reloading the browser tab.
- **Connectivity Dependency:** As a web-based platform, the system's performance is strictly tied to the reliability of the UCU campus network. There is currently no offline mode for lecturers to draft submissions without an active internet connection.
- **Digital Literacy Variations:** Some users, particularly senior academic staff who are less familiar with digital platforms, may require additional training to use the system effectively.

5.3 Problems Encountered

During the development and implementation phases, several challenges were navigated:

- **Requirement Volatility:** Given the Agile nature of the project, frequent feedback during Sprint Reviews often led to the discovery of "edge cases" in the UCU examination policy that necessitated immediate changes to the database schema and routing logic. This required flexibility and rapid adaptation from the development team.
- **Stakeholder Availability:** Coordinating interviews and testing sessions with senior academic staff and the Chief Examiner proved difficult due to their demanding administrative schedules, which occasionally led to delays in requirement validation. To mitigate this, the team scheduled sessions well in advance and prepared concise, focused discussion points.
- **File Integrity and Size Constraints:** Implementing a secure method for large-scale document uploads while maintaining file integrity across different PDF versions required significant troubleshooting of server-side configurations. The

team ultimately implemented file size limits and format validation to address these issues.

- **Integration with Existing Systems:** Ensuring that UEMS could work alongside existing university systems (such as the student records database) without conflicts required careful API design and coordination with the university's IT department.

5.4 Recommendations and Future Research

To further enhance the UEMS and ensure long-term scalability, the following actions are recommended:

- **WebSocket Integration:** To resolve the real-time synchronisation limitation, future iterations should integrate WebSocket technology (such as Socket.io). This will enable a "push" notification system, ensuring that status updates and comments are reflected across all user dashboards instantly without manual refreshes.
- **Dynamic Watermarking:** To mitigate the risk of unauthorised screen captures, the system should implement dynamic, user-specific watermarking. During moderation, the system would overlay the moderator's name, IP address, and a timestamp on the paper, creating a strong deterrent against leaks and ensuring non-repudiation.
- **Pilot with Real Users:** A controlled pilot study should be conducted within the Department of Computing during the next examination cycle. This will provide the "live" data necessary to complete the final objective of formal system evaluation and will help identify any unforeseen issues before university-wide deployment.
- **Automated Plagiarism and Formatting Checks:** Future research should explore integrating Machine Learning (ML) modules to automatically check submitted papers for formatting compliance and potential plagiarism against previous examination banks.

- **Offline Capability:** Developing a progressive web application (PWA) version with offline capabilities would allow lecturers to draft and prepare examination papers without an active internet connection, with automatic synchronisation once connectivity is restored.
- **Training Programme:** A structured training programme should be developed for all user categories to ensure smooth adoption of the system. This should include user manuals, video tutorials, and hands-on workshops.

5.5 Conclusion

The Unified Examination Management System represents a significant technological milestone for Uganda Christian University. By replacing a fragmented, paper-heavy process with a centralised, role-based digital platform, the project has successfully addressed the core issues of inefficiency, security vulnerability, and lack of accountability that plagued the legacy manual system.

The successful delivery of a working system ready for pilot use demonstrates the efficacy of the Agile Scrum methodology in tackling complex institutional workflows. The system meets the primary objectives of automating the examination paper lifecycle, providing role-based access control, maintaining a comprehensive audit trail, and enforcing deadlines through automated reminders.

While technical challenges such as real-time synchronisation and screenshot prevention remain to be fully resolved, the foundational infrastructure for a secure, sustainable, and modern examination management process is now firmly in place. The pending evaluation objective will provide quantitative validation of the system's impact on efficiency and cost reduction.

Full adoption across other faculties will undoubtedly secure UCU's position as a leader in educational technology integration within Uganda's higher education sector. The lessons learned and the technical framework developed through this project can serve

as a valuable reference for similar digital transformation initiatives at other institutions facing comparable challenges.

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TEAM CONTRIBUTIONS

The Unified Examination Management System (UEMS) was developed collaboratively by the following team members. Each member's specific roles and contributions are detailed below.



Joseph Okolimo

M23B13/073

Role: Project Lead & Full-Stack Developer

- Led the overall project coordination, sprint planning, and Agile Scrum ceremonies throughout the five development sprints.
- Designed and implemented the complete system architecture, including the Model-View-Controller (MVC) pattern and workflow automation engine.
- Developed the backend infrastructure using Supabase (PostgreSQL), including database schema design, authentication, and RESTful API integration.
- Built the core workflow modules: secure paper upload, automated routing, deadline enforcement, and digital sign-off functionality.
- Integrated automated email notification system for deadline reminders and task assignments.
- Wrote major sections of the Methodology chapter, including the Agile Scrum framework, system design, and technology stack.



Emelda Nakacwa

M23B13/059

Role: Solutions Architect & Quality Assurance

- Designed the system architecture blueprints, including the digital workflow diagram (Figure 3.1) and UI wireframes for all role-based dashboards.
- Led requirements gathering through key informant interviews with the Chief Examiner, lecturers, and quality assurance staff.
- Defined functional and non-functional requirements, including security specifications and performance benchmarks.
- Conducted User Acceptance Testing (UAT) after each sprint, gathering stakeholder feedback for iterative refinement.
- Performed security testing to validate Role-Based Access Control (RBAC) and audit trail integrity.
- Managed the LaTeX document structure, formatting, and integrated the complete report.
- Wrote the Introduction, Background, Problem Statement, and contextual perspectives of UEMS within UCU.



Robert Ssekisonge

M23B13/056

Role: Frontend Developer & System Security Analyst

- Developed all user-facing interfaces using TypeScript and Tailwind CSS, including dashboards for Setters, Vettors, Team Leads, and the Chief Examiner.
- Implemented responsive UI components to ensure accessibility across different devices and screen sizes.
- Conducted security analysis, including penetration testing and validation of Time-Based Access Control mechanisms.

- Assisted with stakeholder interviews and requirement refinement during sprint planning sessions.
- Researched and documented limitations of browser-level security (screenshot prevention) and proposed dynamic watermarking as an alternative solution.
- Wrote the project objectives, scope, justification, and significance sections.
- Developed the workplan, budget alignment, and ensured adherence to academic timelines.
- Contributed to the Conclusions and Recommendations chapter, particularly the future research directions.

All team members contributed to the writing, review, and editing of the final report. Regular team meetings, sprint reviews, and collaborative coding sessions ensured the successful delivery of the UEMS system.

APPENDIX: SYSTEM USER MANUAL

A.1 Login Instructions

Authorised users can access the UEMS system at the hosted URL. Login credentials are provided by the system administrator. First-time users should reset their password upon initial login.

A.2 Role-Specific Functions

A.2.1 Lecturer/Setter Functions

6. Navigate to the examination dashboard
7. Upload examination paper in PDF format
8. Confirm submission before the deadline
9. Track revision requests from moderators

A.2.2 Moderator/Vetter Functions

1. Access assigned papers for review
2. Complete digital checklist based on Bloom's Taxonomy
3. Add comments and suggestions
4. Approve or return papers for revision

A.2.3 Chief Examiner Functions

1. Activate examination cycles
2. Set submission deadlines
3. Assign team leads, setters, and vetters
4. Provide final approval for examination papers