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Development of an Intelligent Management Information System (IMIS) to Optimize Operational Efficiency in the Computer Engineering Department, Enugu State University of Science and Technology (ESUT),Nigeria

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ABSTRACT

This study entitled "Development of an Intelligent Management Information System to Optimize Operational Efficiency in the Computer Engineering Department, Enugu State University of Science and Technology (ESUT)" focuses on the design, implementation and deployment of an Artificial Intelligence (AI)-based Management Information System (MIS) aimed at improving operational efficiency in the Department. Developed during the 2024/2025 academic session, the study addresses persistent challenges such as slow administrative processes and poor data coordination, which are common in academic institutions. By incorporating AI technologies, the system aims to automate tasks, optimize resource management, and provide tailored academic support. A detailed requirements analysis showed that most users were between 25 and 35 years old (62%) and actively engaged in academic pursuits: 48.9% held or were pursuing BSc degrees, 28.9% MSc and 22.2% PhDs. The gender distribution were nearly even; thus emphasizing the need for an inclusive and user-friendly platform. Key issues in the existing system included sluggish performance, frequent downtime, and a cumbersome interface. Respondents called for faster response times (31.1%), improved usability (20%), and more efficient backend operations (15.5%) as reflected in the results of the survey. There was strong interest in AI-powered features such as intelligent academic data processing, curriculum mapping (24.4%), and secure authentication through biometrics or facial recognition (31.1%). The system was developed using Semantic Versioning and built on the CodeIgniter framework, applying a Model-View-Controller (MVC) architecture with Hierarchical Model-View-Controller (HMVC) for modular and maintainable development. It integrates client/server communication, event-driven logic, database-focused operations, and object-oriented design to ensure performance and scalability. Core functionalities include predictive analytics, real-time user assistance through natural language processing, and a flexible structure capable of supporting future expansion. This project highlights AI's potentialities to transform educational administration, streamline operations, and enhance academic delivery. The study recommends the adoption of the AI-MIS as a sustainable and effective replacement for the current University digital system, given its innovative capabilities and alignment with institutional goals.

Keywords: Artificial Intelligence, Management Information Systems, Higher Education, Operational Efficiency, Educational Technology, GPT-API, PHP, MySQL

INTRODUCTION

Educational institutions today face significant challenges in maintaining operational efficiency, academic excellence and financial stability. Among the most pressing of these issues is administrative inefficiencies. Traditional management approaches often fall short in addressing these complexities. An Integrated Artificial Intelligent Powered Management System (IAPMS) emerges as a promising solution, offering automation, real-time insights, and advanced data handling to support institutional operations and strategic planning [1], [2]. The increasing prominence of artificial intelligence (AI) research and technologies can be attributed to several key factors. Such include: technological advancements in areas of microprocessors, data storage, and global networking which have significantly enhanced computational capabilities, facilitating the development of AI systems. Additionally, the growing availability of large datasets has enabled more effective machine learning models. The widespread adoption of AI across various industries, driven by its potential to improve efficiency and innovation, has further accelerated research and adoption in the field. Moreover, the integration of AI into entrepreneurship practices has opened new avenues for research, prompting scholars to explore its impact on business strategies and outcomes. These developments underscore the transformative role of AI in contemporary research and its expanding influence across multiple sectors [3]. As [3] noted, the convergence of AI with entrepreneurship is reshaping research landscapes, necessitating a proactive approach to harness its potential. This study intends to give a thorough grasp of how AI can be strategically applied to transform educational management by looking at current issues and possible solutions; and thus add to the expanding corpus of information on AI in educational administration. This study therefore aim at the "Development of an Intelligent Management Information System to Optimize Operational Efficiency in the Computer Engineering Department, Enugu State University of Science and Technology (ESUT)". The specific objectives include: to collect data and insights about the need and features of the proposed system (requirement analysis), to design the architecture and user experience of the proposed system, to implement AI-driven automation for handling student inquiries, analyzing feedback, and sending notifications using Natural Language Processing (NLP) via a Generative Pre-trained Transformer (GPT) Application Programming Interface (API), to train the AI to be able to process large data volumes and increasing user demands, ensuring reliability and performance under varying loads; to deploy the artefact to server and to test the artefact ensuring data processed provides accurate results.

REVIEW OF RELATED LITERATURES

Intelligent Management Information Systems in the Universities

The integration of Intelligent Management Information Systems (IMIS) in higher educational institutions has gained significant traction due to the growing demand for automation, data-driven decision-making, and personalized student experiences. IMIS combines traditional Management Information Systems (MIS) with Artificial Intelligence (AI), allowing for advanced data processing, pattern recognition, and intelligent automation [4]. These systems enhance administrative efficiency, academic planning, resource allocation, and overall institutional governance.

Evolution of Management Information Systems in Higher Education

Traditionally, MIS in universities were focused on automating routine administrative tasks such as admissions, registration, grading, and timetabling [5]. While these systems improved operational efficiency, they lacked the capacity for predictive analytics and adaptive decision-making.

As digital transformation accelerated, there emerged a shift toward intelligent systems that incorporate machine learning, natural language processing, and data analytics to manage large volumes of structured and unstructured educational data [6]. This evolution marked the transition from static data repositories to dynamic, learning-enabled systems.

Core Components of Intelligent MIS

An Intelligent MIS typically includes the following components:

1. Data Integration Layer – Consolidates data from multiple university departments.
2. Analytics Engine – Uses AI/ML for pattern detection and forecasting [7].
3. Decision Support System (DSS) – Provides actionable insights for academic planning and student interventions.
4. Personalization Module – Tailors content and services to student needs, such as personalized learning pathways [8].
5. Automation Services – Manages workflows like course scheduling and grading using AI-driven logic.

Applications in University Settings

Student Performance Prediction

IMIS are increasingly applied in early warning systems that flag at-risk students based on attendance, grades, and learning engagement [9]. For instance, AI models trained on historical academic data can predict students' likelihood of graduation or drop-out, enabling proactive interventions [10].

Administrative Automation

AI-based IMIS streamline course registration, resource allocation, and faculty scheduling through intelligent agents that learn from usage patterns and optimize workflows [11].

Curriculum Planning and Evaluation

Some universities leverage intelligent systems to optimize curriculum offerings by analyzing labour market trends, alumni outcomes, and student feedback [12].

Research and Grant Management

IMIS also support academic research by providing tools for automated grant matching, research output tracking, and collaboration suggestions based on faculty expertise and research history [13].

Challenges and Limitations

Despite their benefits, IMIS implementation in universities faces several challenges:

- Data Privacy Concerns: Managing sensitive student and faculty data while complying with regulations like General Data Protection Regulation (GDPR) remains a key issue [14].
- Technical Complexity: Integration with legacy systems, diverse data formats, and the need for real-time processing require advanced IT infrastructure [15].
- Ethical Considerations: Using AI for decision-making in education raises ethical questions about bias, transparency, and accountability [16].

Future Directions

The future of IMIS lies in adaptive learning environments, blockchain integration for secure academic records, and predictive analytics for institutional planning. Further research is needed on the ethical AI deployment in education, particularly in decision-making systems that affect student outcomes [17].

Software Development Life Cycle

The Software Development Life Cycle (SDLC) provides a structured framework for planning, developing, testing, and deploying information systems [18]. It ensures that software development aligns with technical requirements and user expectations, emphasizing quality assurance throughout [19].

SDLC Phases - Software Development Life Cycle (SDLC) entails the following phases [20], [18], [21], [19]**:**

Initiation: The project sponsor identifies system needs and submits a concept proposal for executive approval.

Concept Development: Scope definition and planning documents like feasibility studies and risk analyses are prepared.

Planning: Development of project management strategies, including acquisition and operational plans.

Requirements Analysis: Functional and technical requirements are defined, documented in Software Requirements Specification (SRS), and accessibility considerations are integrated.

Design: Technical specifications are derived from requirements, including database and interface design.

Development: Implementation of code and infrastructure, along with documentation such as development reports and contingency plans.

Integration and Testing: Testing phases verify that requirements are met and defects are identified before deployment.

Implementation: Deployment of the system, user training, and a post-implementation review to ensure delivery success.

Operations and Maintenance: Ongoing system monitoring, updates, and revisions ensure system longevity and user satisfaction.

Disposition: Safe decommissioning of systems, preserving critical data and supporting potential future reinstalls.

SDLC Models

Waterfall Model: A linear, sequential approach best suited for well-defined projects; emphasizes upfront planning but lacks flexibility [22]. Incremental Model: Combines Waterfall's structure with iterative delivery; allows phased releases but requires thorough upfront planning [23]. Spiral Model: Merges prototyping and Waterfall; emphasizes iterative risk analysis; ideal for large, complex projects [24].V-Shaped Model: Extension of Waterfall with corresponding testing phases; provides high reliability for small, well-scoped projects [25].

Model Selection

The choice of SDLC model depends on project type, risk, size, user interaction, and requirement stability. Hybrid approaches are common in practice to leverage strengths across models [22], [23].

MATERIALS AND METHODS

Materials

The project implementation relied on both hardware and software resources.

Hardware Components:

1. Development Workstation
   - CPU: Intel Core i7 (10th Gen)
   - RAM: 32 GB DDR4
   - Storage: 512 GB – 1 TB SSD + 1 TB HDD
   - GPU: NVIDIA RTX 3060
   - Monitor: 14" Full HD (dual optional)
   - OS: Windows 10
   - Power: 1.5 kVA solar backup
2. Cloud Computing Resources
   - Google Cloud (TPUs/GPUs), AWS Nigeria resellers for managed cloud services.
3. On-Premise Server Infrastructure
   - CPU: Intel Xeon
   - RAM: 64 GB ECC
   - Storage: 512 GB SSD + 2 TB HDD
   - OS: Ubuntu Server
4. Networking Equipment
   - Router: TP-Link Archer AX23/Ubiquiti
   - Switches: 8–24 port Gigabit (TP-Link)
   - Firewall: pfSense
5. Power Protection & Peripherals
   - External USB 3.0 backup drives
   - Ergonomic workspace
   - Webcam and microphone
6. Mobile Testing Devices
   - Android: Samsung/Infinix/Tecno
   - iOS: iPhone
   - Optional tablets (Samsung Tab/iPad)

Software Components:

- AI/ML Development: Python
- Backend: Java
- Database: MySQL
- Frontend: React
- Cloud Platform: Google AI Platform
- Security: OpenID Connect, JWT
- DevOps: GitLab, Jenkins, GitHub Actions
- Testing: Postman, PyTest, JUnit, Selenium, SonarQube
- Visualization: Power BI, Tableau, Plotly, Grafana
- Project Management: MS Project, Teams, Notion/Confluence

Methodology

1. Requirement Analysis (Data Collection)

Data was collected via structured questionnaires targeting students, academic, and administrative staff to assess the need for an Intelligent Management Information System (IMIS). Out of 50 questionnaires, 45 were returned valid and analyzed statistically. (Appendix I)

2. Software Versioning

The project utilized Semantic Versioning to manage iterative software development, enabling collaborative efforts and version control. Each software release followed a structured versioning format (major.minor.patch), enhancing traceability and feature evolution [26], [27].

3. System Architecture

The software design followed Model-View-Controller (MVC) architecture and adopted multiple architectural styles:

- Client/Server: Separates user interface (client) and business logic (server).
- Event-Driven: System operations are triggered by user actions/events.
- Database-Centric: Heavy reliance on database-driven logic.
- Object-Oriented: Modular components represented as objects.

4. Framework

The implementation used the CodeIgniter framework, loosely based on MVC, but adaptable to Hierarchical MVC (HMVC) for modular design.

5. Controller Design

Three main controllers were implemented:

- Admin Controller: Handles user management, content creation, and system admin tasks.
- Home Controller: Manages front-end user interactions and content display.
- Install Controller: Manages initial system setup, including database and site configuration.

6. Use Case & Diagrams

- Login Sequence Diagram: Visual representation of authentication flow.
- Relational Schema Diagram: Illustrates database table relationships and structure (see Figures 1 and 2).

Login Sequence Diagram

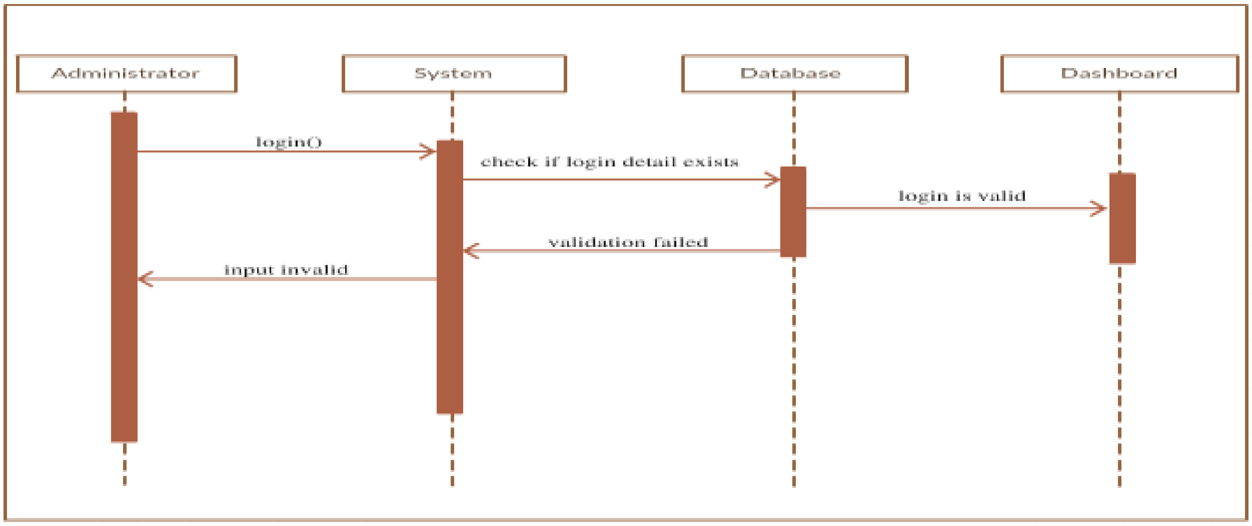


Figure 1 Sequence diagram for login

Relational Schema

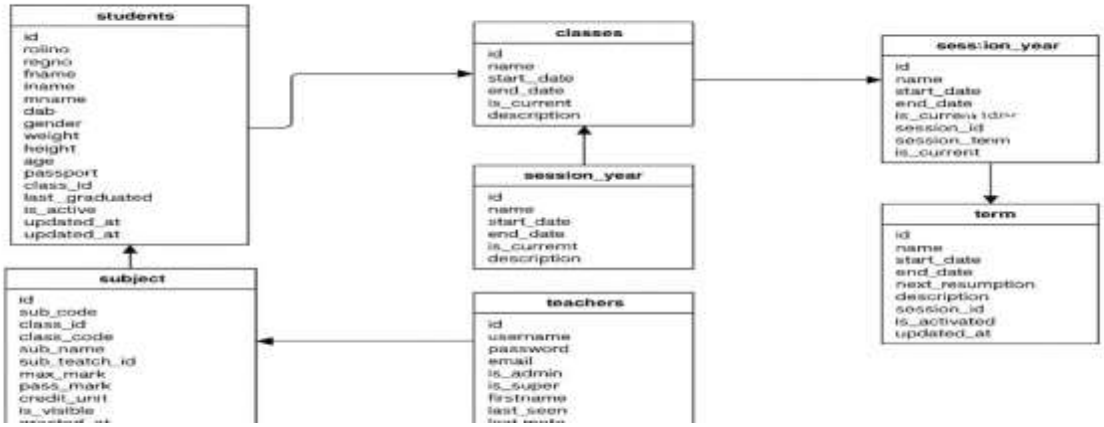


Figure 2: Relational Schema diagram

RESULTS AND DISCUSSION

Requirement Analysis - Insights about the need and features of the proposed system

Socio-demographic Characteristics of Respondents

Age Distribution of Respondents

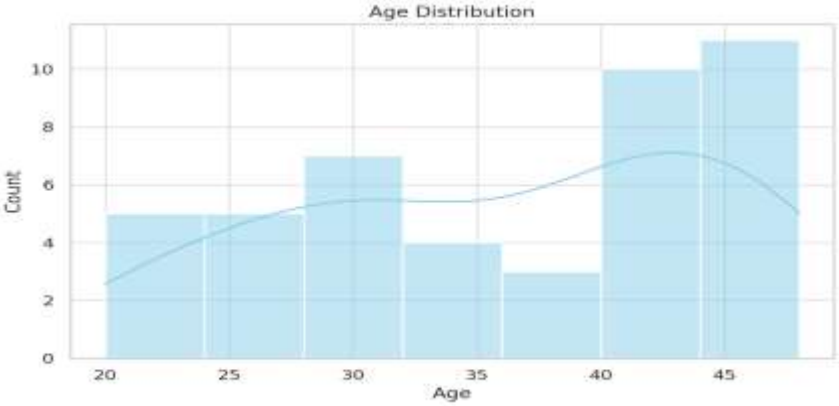


Figure 3. Age Distribution of Respondents

The data reveals that respondent ages range from 20 to 48 years, with a majority concentrated between 25 and 35 years (Fig 3). Specifically, 62% of respondents fall within the 25–35 age group, 21% are between the ranges of 20–24, while the remaining 17% are aged 36–48. This suggests that digital platform is predominantly used by a younger, academically active demographic, likely comprising university students and early-career researchers. Previous studies have indicated that younger users are more digitally engaged and often rely on web platforms for academic and professional purposes [28], [29].

Sex Distribution of Respondents

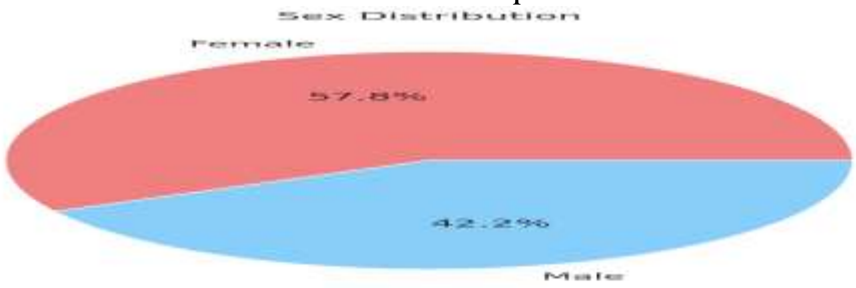


Figure 4. Sex Distribution of Respondents

The gender distribution appears relatively even, indicating active engagement from both male and female users (Fig 4). Specifically, 52% of respondents identified as female and 48% as male. This reinforces the need for inclusive and accessible website design that caters to a broad and diverse user base. Research supports the importance of gender-sensitive digital environments to enhance user experience and equitable access [30], [31].

Educational Level of Respondents

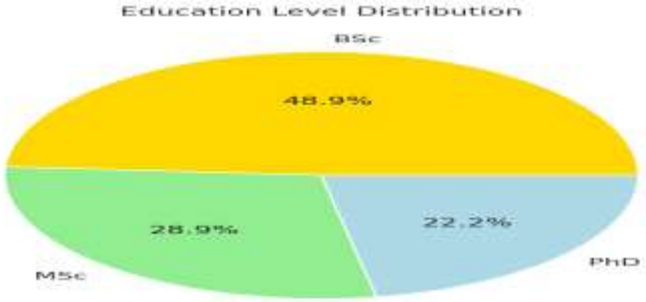


Figure 5. Educational Distribution Level of Respondents

Most users reported either being enrolled in or having completed undergraduate (BSc) programs, followed by master's (MSc) and doctoral (PhD) levels (Fig 5). Specifically, 48.9% of respondents reported BSc-level education, 28.9% held or were pursuing MSc degrees, and 22.2% were at the PhD level. This pattern highlights the platform's use among an academic audience. For such users, a website must prioritize credibility, usability, and efficient access to scholarly resources, aligning with the findings of studies focused on educational web design and user behavior in digital learning environments [32], [33].

Challenges in the existing system

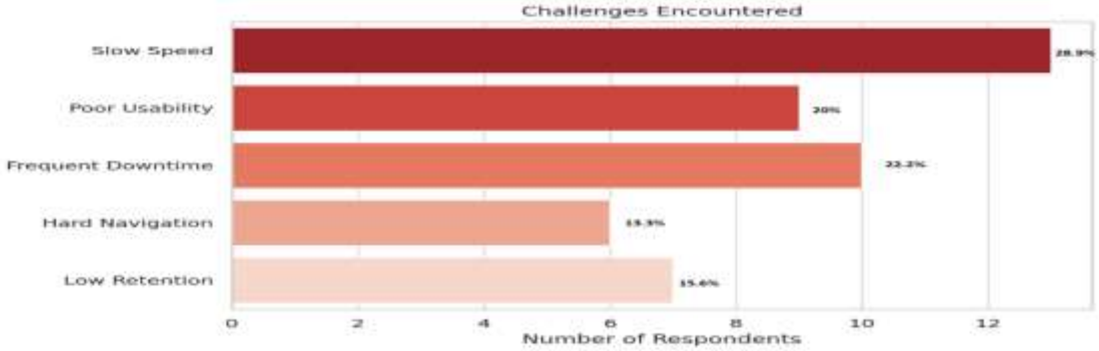


Figure 6. Challenges encountered by Respondents

The data in Figure 6 illustrates the key challenges reported by users of the current system. The distribution is as follows: low speed (28.9%), frequent downtime (22.2%), poor usability (20%), low retention (15.6%), and hard navigation (13.3%). These findings align with prior studies that identify performance issues, poor design, and system unreliability as major factors affecting user satisfaction and system effectiveness [34], [35]. Slow website response times and usability problems have consistently been shown to degrade the user experience and increase user frustration [6]. Moreover, frequent downtimes and difficult navigation disrupt the continuity of use, contributing to lower retention rates [36]. These results suggest the need for targeted improvements in system speed, interface design, and backend stability to enhance overall user satisfaction and retention.

Preferred Solutions to Challenges in the existing system

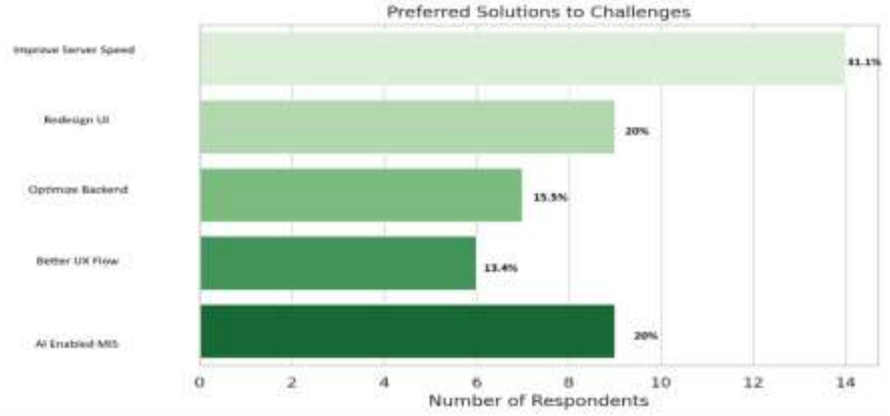


Figure 7. Preferred features by Respondents

The following are the responses of the respondents on the preferred features to the proposed artefact: 31.1% expected an improved server speed, 20% wants a robust user interface (UI), 15. 5% expected an optimized backend, 13. 4% subscribed to a better user experience (UX) flow, 20% wants an enabled management information systems (MIS). The respondents preferred features target the core technical innovation of a modern University: improving server speed, redesigning the user interface, backend optimization, and enhancing the user experience flow. These solutions show a clear user demand for system upgrades and user-centric design enhancements. These expectations tallied with similar results of: [37], [38] and [39].

Features expected to be sustained in the Proposed System

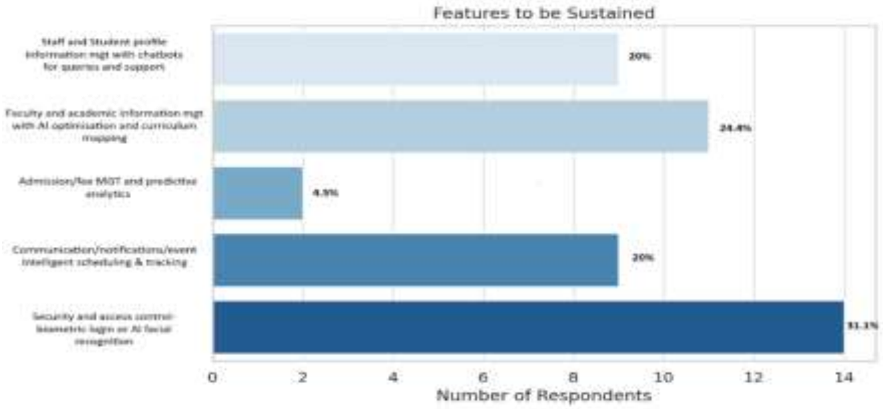


Figure 8. Features Respondents wants Sustained

Results from the respondents on the features to be sustained on the proposed IMIS for the department indicated the following: 20% of the respondents subscribed to the integration of staff and students profile information management with chatbots for support and queries. 24.4% opted for faculty and academic information management with AI optimization and curriculum mapping. 4.5% indicated admission/fee management and predictive analytics. 20% for communication/notification/event intelligent scheduling and tracking. 31.1% expected the proposed artefact to sustain security and access control through biometric login or AI facial recognition. This varied responses reflects the features that users find most valuable and want to be integrated in the proposed MIS artefact. This suggests these components are central to a good user experience. These responses laid credence to similar results of studies by: [40], [41], [42], [43] and [44].

Implementation I: Preliminary Design and Development

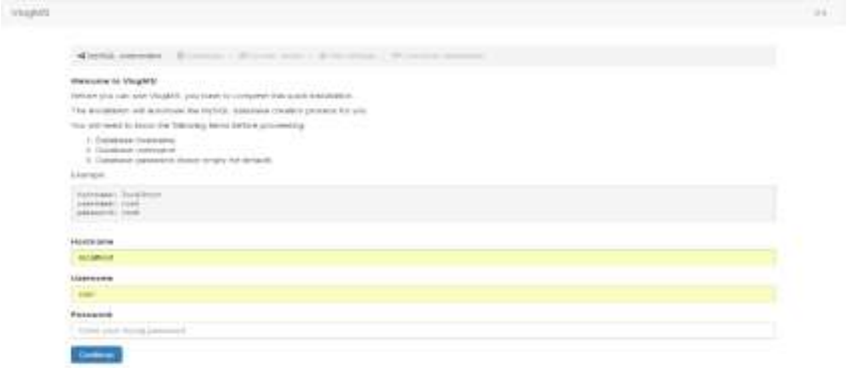
The AI system comprises two primary interfaces: the Content Management Application (CMA) and the Continuous Delivery Architecture (CDA). The CMA serves as the user interface within the artefact, enabling users to create, manage, and edit content without requiring knowledge of HTML or other technical coding languages. This design allows for easy content management on websites or other digital platforms [45]. The CDA functions as a central interface accessible solely by system administrators and authors. It includes features for publishing content and managing the views of the front-end interface. The CDA currently offers two access levels: Administrator and Author. The Administrator has full system access, while the Author has limited features compared to the Administrator.

Implementation 2: Setup Configuration

Before the system can be utilized, the administrator must complete a setup configuration phase. This process involves setting up a MySQL connection, creating a database, automatically generating SQL tables, and defining site settings such as Administrator login details and website information [46]. After successfully adding this information, a "Complete Installation" page appears, prompting the administrator to finalize the installation. Upon completion, installation files are deleted for security reasons.

Results 2 for Setup Configuration

When installing on a local system, the default hostname is "localhost," and the default username is "root." Passwords are typically not specified by default on localhost installations, allowing the password field to remain blank unless the user sets a password for the root user, in which case it must be specified [46]. After a successful connection, the user is directed to the database creation page, where they can enter the desired database name. The database is then created automatically. If an error occurs during this process, the database is not created, and the user is prompted to retry until successful.The following are screenshot samples demonstrating the installation process:



VlogMS

MySQL connection

Welcome to VlogMS!

Before you can use VlogMS, you have to complete this quick installation.

The installation will automate the MySQL database creation process for you.

You will need to know the following items before proceeding.

1. Database hostname
2. Database username
3. Database password (leave empty for default)

Example:

```
hostname: localhost
username: root
password: [illegible]
```

Hostname

localhost

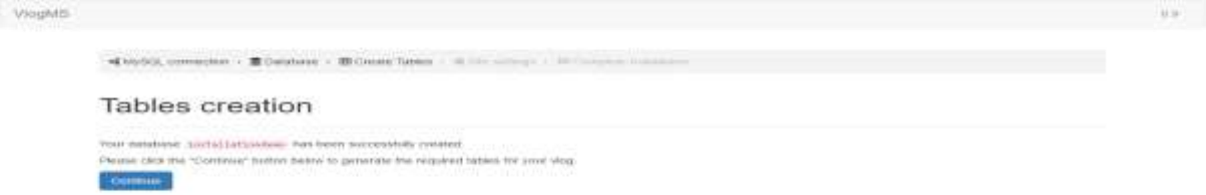
Username

root

Password

[illegible]

Figure 9. First Page of the Installation Process



VlogMS

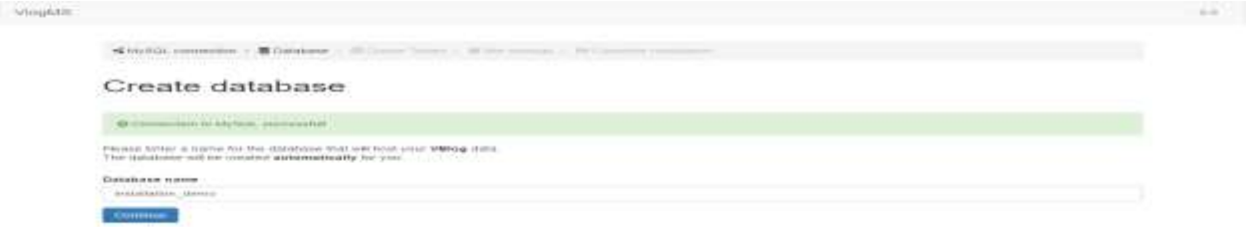
MySQL connection › Database › Create Tables › Site settings › Complete installation

Tables creation

Your database installationdemo has been successfully created.

Please click the "Continue" button below to generate the required tables for your vlog.

Figure 10: shows connection has been successful and user would be asked to enter a desired name for MIS database



VlogMS

MySQL connection › Database › Create Tables › Site settings › Complete installation

Create database

Connection to MySQL successful

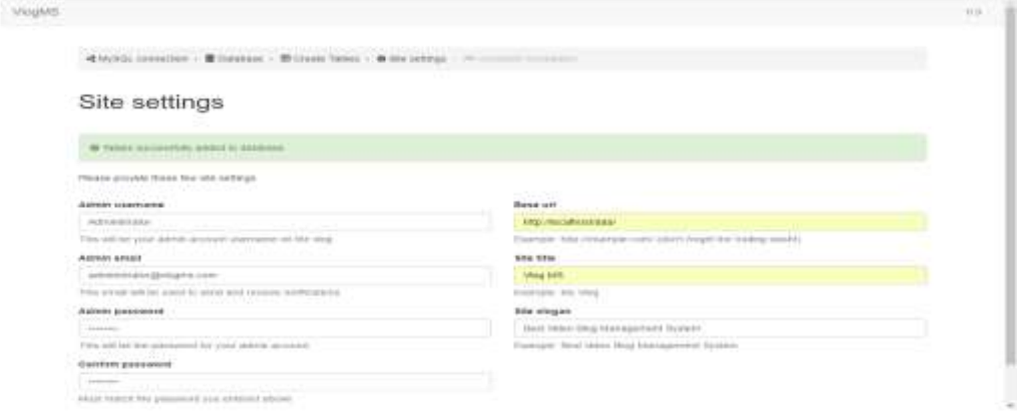
Please enter a name for the database that will host your VBlog data.
The database will be created automatically for you.

Database name

installation_demo

Figure 11: shows database creation was successful then user is asked to click continue to create required tables

After database creation is successful user is taken to the next phase where "Continue" button has to be clicked to create tables required for the system to operate properly.



VlogMS

MySQL connection › Database › Create Tables › Site settings › Complete installation

Site settings

Admin username

Admin email

Admin password

Confirm password

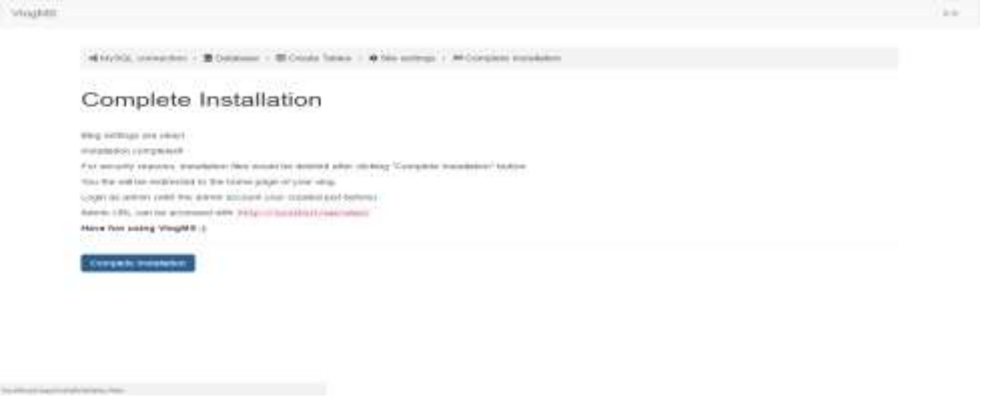
Base url

Site title

Site slogan

Figure 12: shows a sample how site settings are provided

On this page is where the administrator is created for the MIS along with some basic settings for the site.



VlogMS

MySQL connection › Database › Create Tables › Site settings › Complete installation

Complete Installation

Have fun using VlogMS :)

Figure 13: complete installation page

This is the final page of the installation process after clicking "Complete Installation" files associated with the installation process would be permanently delete so someone with ill-intentions would not have access to this file and use them to their own advantage as against that of the administrator. Although, restrictions have also been made so this process cannot be repeated it is just safer to delete the files rather than leave them to chance.

Implementation 3: Login and Landing Page

There are two landing pages: the first for administrators and the second for users. For administrators the landing page known as "Dashboard" is shown after their login has been verified. Although users' login has not been fully implemented on the system, Administrators can still add users and authors so they can post. User registration would be fully implemented in later version of the system. Currently only guest browsing is available.

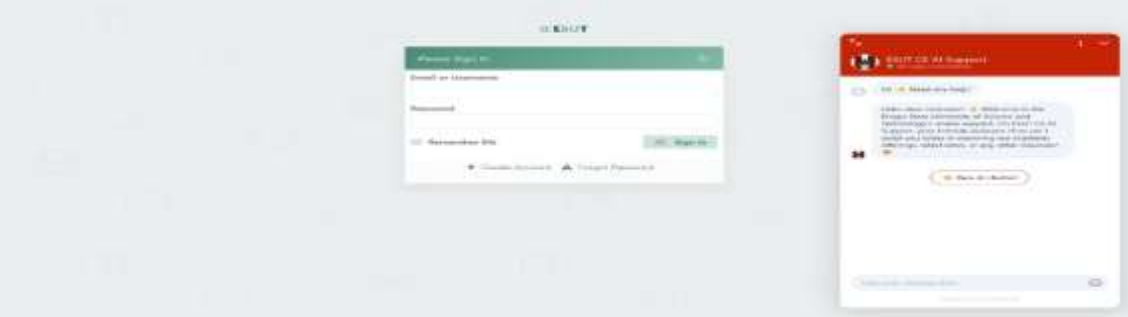


Fig 14. Login and Landing Page

Result 3: Login and Landing Page

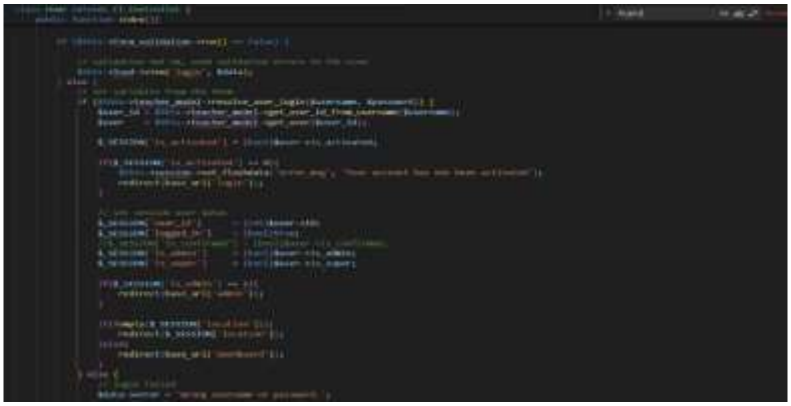


Figure 15: shows the code associated with the login

The first two lines in the login code sets validation of login input from the user to the respective fields. On the first line the *username* field is specified and is set to accept only alpha-numeric values and is also required while the *password* field just set to be required. The code also has nested if statements; the first statement runs when the “login” button is clicked, the statement returns false if the validation does not correspond with the validation that has been set in the first two lines. If the statement returns true, the else block would run. Here, the values inputted would be stored in respective variables then the nested *if* statement within the *else* block would run. The if resolves user login with the *resolve_user_login* method if this validation is okay, if the values entered corresponds with values in the database. Then it returns the user unique along with the entire user information in the row. The values retrieved from the row are stored in session variables either as Integer, String or Boolean depending on the value being stored in the session. The nested *if* also has a nested *if* that checks if the user trying to login is either an admin or an author, if not it returns a notice telling the user “Only Administrator permitted”. The last *else* statement runs when the *resolve_user_login* method returns false which happens when username or password does not correspond with any value in the database.

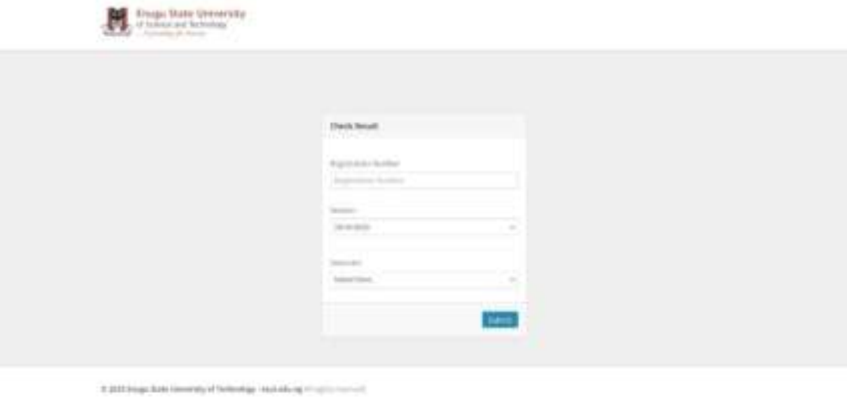


Figure 16 shows sample of the dashboard

Implementation 4: Headers

The website has a global header throughout the pages. It contains navigations to various pages as specified by the user.

Result 4: Header

The default header navigations specified by the system are placeholders for values specified by the user, this includes the website title *et cetera*. Also, the search bar has been specified by default as a header content. The other navigations and respective pages has to be created by the user in the CDA.

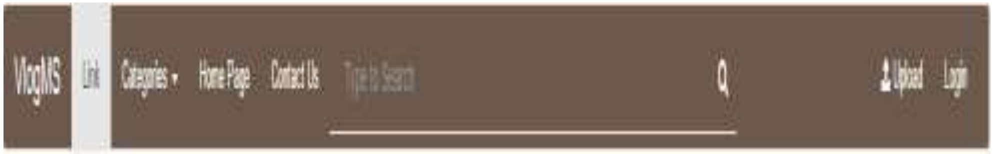


Figure 17. Sample design of header content and navigations

Implementation 5: Testing and Evaluation

Throughout the history of software/application development, no software is truly complete until the software is fully tested. The testing covered the following areas: functionality check, security test for vulnerabilities and also test to prevent regression. The main focus of testing was to ensure that the deployed system meets user standards for the operations described and to function as expected especially in relation to the objectives of the study.

Results 5: Testing and Evaluation

The system underwent testing using the peer review method. Version 001 was distributed to various respondents, who were instructed to use the system in different ways. They then reported any issues encountered and areas where the system could be improved or enhanced with additional features. One significant security issue identified during this testing was a Cross-Site Scripting (XSS) vulnerability in the comments section, which was subsequently patched [47-48]. The project was evaluated based on two variables: a user-centered AI Management Information System and a user-friendly content delivery application. The evaluation assessed how effectively these variables were achieved:

- **User-Centered AI Management Information System**: The project was developed using the Model-View-Controller (MVC) architectural structure to ensure interoperability and robustness when handled by users [48]. The system's model communicates with data from users, the controller interprets this data, and the view presents the output. The system is user-centered because accessibility issues have been addressed. Content sections are clearly defined, users can easily browse through content by simply searching, navigational elements are user-defined, and pagination has been implemented to eliminate issues with scrolling through extensive content.
- **User-Friendly Content Delivery Application**: Designing a user-friendly system and content delivery application posed a significant challenge and resulted in extensive time consumption. Several components,

APIs, libraries, and architectures were utilized to ensure the system's flexibility. The system's flexibility is demonstrated through its architectural design and development, as well as its functionality. The deployed system showcases the operation of these components and their robustness.

CONCLUSION AND RECOMMENDATIONS

CONCLUSION

The study titled "Development of an Intelligent Management Information System to Optimize Operational Efficiency in the Computer Engineering Department, Enugu State University of Science and Technology (ESUT)" was conducted during the 2024/2025 academic session. It aimed to design a modern, AI-enabled Management Information System (MIS) to address key inefficiencies in the current system. A requirement analysis revealed that users - mainly young and academically active - faced challenges like: system slowness, downtimes, and poor usability. Respondents expressed a strong preference for AI features, including academic data management, curriculum mapping, and biometric security. Following the Software Development Life Cycle (SDLC), the project incorporated advanced technologies such as machine learning for performance forecasting, natural language processing (NLP) for real-time support, and scalable system architecture for reliability under high demand. The user interface was tailored to support students, academic advisors, and administrators, simplifying tasks like result management, course registration, and communication. The developed AI-MIS was tested and received positive feedback from all users. It successfully integrated critical academic and administrative functions, including academic record keeping, fee management, real-time Q&A systems, and mobile-responsive design. Its AI capabilities enhanced user support, academic advising, and security; marking a significant improvement over the current system.

RECOMMENDATIONS

Based on the performance and innovative features of the artefact, the study recommends that the University adopt the developed AI-MIS model as a sustainable and effective replacement for the existing website, positioning it as a future-ready digital solution for higher education management.

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