



Research Article

Design and Implementation of an Artificial Intelligence-Augmented Learning Management System (EduSync)

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Abstract

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The fragmented platforms in Nigerian universities do not offer personalization, real-time interaction, or Artificial Intelligence features, making it difficult for both students and lecturers. This platform was developed using the Incremental Software Development Model through eight stages. The frontend consists of React 18, TypeScript, and Tailwind CSS, while the backend is based on the Supabase PostgreSQL database. The GROK (Llama) API enables the automated assessment engine to function properly. All performance objectives were achieved, including logging in within 1-2 seconds, loading the dashboard within 1-3 seconds, and submitting assignments within 2 seconds. The role-based access control system effectively restricted any form of unauthorized access, while the AI grading engine provided instant feedback with complete lecturer override functionality. EduSync has made lecturers' workloads less burdensome and students more organized by using AI to automate processes, demonstrating that efficient and intelligent LMS systems can transform the Nigerian university system.

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I. INTRODUCTION

Digital technology innovations have made the Learning Management System (LMS) one of the essential aspects of higher education. Nevertheless, most digital platforms are too generic or poorly integrated to satisfy the requirements of learners, tutors, and administrators. Modern institutional management systems like UMIS and SIS perform limited functions and force students to coordinate their activities across several platforms, which leads to inefficiency and low academic performance [3].

AI technologies have made it possible to create unified platforms for managing academic activities along with personal management tools, enhancing collaboration among individuals and helping students establish and accomplish their objectives efficiently. At Babcock University, there is an increasing demand for interactive LMS applications, but all available platforms possess basic functionalities with no personalized learning capabilities or AI assistance [1]. This paper presents EduSync, an AI-integrated, web-based Learning Management platform that integrates educational services with student management. The platform helps learners better organize their academic and personal

responsibilities, lecturers minimize their efforts on assessments, and administrators gain a clear overview of students' status [16]. The GROK (Llama) API facilitates the automation of question formulation and grading, thus making the education process more flexible for everyone. The main contributions of this research are: (i) a role-oriented unified LMS interface with individualized dashboards for students and lecturers; (ii) an AI-enabled assessment module for automated assessment and feedback provision; (iii) an AI-integrated study tool for creating notes and summarizing documents in PDF format; and (iv) an exhaustive evaluation from various perspectives.

II. LITERATURE REVIEW

A. Overview of Learning Management Systems

The rapid development of information technologies has changed the methods of learning, management, and assessment in higher education institutions. Various LMS systems, including Moodle, Blackboard, Canvas, and Google Classroom, are widely used by universities globally. Nevertheless, many of them lack the flexibility, personalized approach, and intelligence required in today's educational environment [3]. Incorporating artificial intelligence (AI) into LMS development allows automatic grading, question creation, recommendations, and even prediction of which students are at risk [4]. The outbreak of coronavirus disease (COVID-19) contributed to the increased adoption of LMSs in Nigeria's higher education system [11]. Nevertheless, poor LMS integration and low levels of personalization and automation revealed serious drawbacks. Students need to access several platforms to receive information on their courses, communication, and evaluation. Moreover, lecturers suffer from high workloads due to manual grading processes [21].

B. Historical Background

LMS has its roots in the 1960s, with computer-based learning tools such as PLATO. However, the 1990s were when LMS came into being through platforms like Blackboard and Moodle, which were able to provide structured content, assessments, and communication functionalities [8]. The following decades saw LMS evolve further owing to cloud computing and mobile computing technologies. In recent years, developments in artificial intelligence have helped make LMS smarter and more adaptable [22]; however, their extensive use is not yet widespread in developing nations because of issues related to infrastructure and training [19]. In Nigeria, the uptake of LMS was greatly increased by the COVID-19 pandemic. Issues such as poor infrastructure, the digital divide, and a lack of adequate training among lecturers and students were major hindrances to effective application [11]. This clearly highlights the urgent need for intelligent LMS systems that adapt to the unique requirements of Nigerian higher education institutions.

C. Overview of Existing Systems

Moodle is an LMS that utilizes open-source software and is highly flexible in terms of its plugin capabilities; yet, it requires substantial technical knowledge for customization [21]. Blackboard Learn has extensive capabilities but is costly to use, and its complicated interface has faced criticism in developing nations. Canvas has a simple web-based interface but lacks advanced AI technologies such as automated evaluations and adaptive pathways. Google Classroom is relatively simpler and more affordable but fails to provide analytics and assessment through AI technologies [7]. Lastly, Microsoft Teams for Education emphasizes collaboration over learning but cannot be used as a full-fledged LMS.

D. Strengths and Weaknesses of Existing Systems

Current Learning Management Systems offer access to learning materials, improved communication facilities, online learning facilities, and cloud scalability [8]. However, there are some common drawbacks across these systems: lack of personalization, separation between learning and personal management tools, difficulties in use by less computer-savvy users [21], expensive licenses for proprietary software applications, and no use of artificial intelligence [22]. Accessibility problems also restrict their use in countries like Nigeria [1].

E. Review of Related Work

Furthermore, Almaiah *et al.* [3] found that although the growth of e-learning use internationally contributed to the digitalization process, it also brought to light difficulties related to usability, technological infrastructure, and technical assistance. According to Ajani *et al.* [2], organizational readiness is a critical factor in the continued adoption of LMS, and its usage rate will be very low if there is insufficient institutional backing and user training. In contrast, the digital divide on the African continent remains common because of infrastructural differences and social disparities, as mentioned by Adako and Ekundayo [1]. Furthermore, according to Zou *et al.* [24], poor interface ergonomics and inconsistent navigation have negative impacts on students' sustained engagement in a mobile LMS environment. This statement was corroborated by the findings of Su *et al.* [21], which showed that deficiencies in digital literacy skills, content overload, and other barriers hindered the integration of Moodle into the curriculum. Okoye and Ikedinachi [16] and Kumar *et al.* [12] pointed out the possibilities of incorporating different artificial intelligence features. ARITEKIN [4] carried out a detailed study on AI-powered LMS from 2020 to 2025 and concluded that deployment was hindered by data privacy issues, financial considerations, and a lack of technical know-how. Bond [5] listed methodological problems, ethical concerns, and scalability limitations as key obstacles to AI adoption in institutions. Qeios [18] performed a bibliometric analysis of trust in AI-empowered education systems and found that

insufficient transparency and the absence of accountability mechanisms continue to affect stakeholders' trust levels.

Lundgren [13], Grévisse *et al.* [10], and Poličar *et al.* [17] evaluated the use of LLMs for grading student assignments, essay writing, and short answers. Their findings were consistent, with efficiency improvements as a common outcome, but potential reliability and fairness issues, such as conservative bias and low sensitivity to context, were also noted. García-Varela *et al.* [9] suggested normalization of rubrics for improved fairness, and MDPI [14] benchmarked grading using GPT-4 against human assessors, concluding parity for simple assessment criteria but continued divergence in complex evaluative thinking. As noted by Chen *et al.* [6], the use of artificial intelligence-powered chatbots provided adaptive feedback and increased motivation; at the same time, there was overdependence on automated support systems. Similarly, according to Zhang and Patel [23], the engagement level achieved using AI-powered LMS systems is high, but these systems usually lack effective learning outcomes without proper guidance from mentors. Mensah and Boateng [15] revealed that although the use of lightweight mobile-first LMS systems increases accessibility, they lack AI capabilities for adaptive learning.

F. Gap Analysis

Even with developments in current learning frameworks, a few weaknesses can be identified. First, some LMS providers

lack personalized learning programs for individual students [3]. Moreover, the academic applications used are available on various platforms, thus reducing efficiency when studying. Current solutions lack robust AI capabilities, including automated question creation, grading, and adaptive feedback. Additionally, issues of fairness and explainability are prevalent [21], [5]. Scalability is another problem caused by internet limitations. Existing learning solutions are geared toward Western schools, making them inappropriate for implementation in developing countries. EduSync resolves these shortcomings through a combination of learning tools and AI functionalities tailored to Nigerian higher learning environments [15], [11].

III. SYSTEM ANALYSIS AND DESIGN

A. System Architecture

This approach uses a three-layer architecture that consists of the Presentation Layer, Application Layer, and Data Layer. The Presentation Layer is concerned with all the user-facing operations performed on the client side in the browser. The Application Layer takes care of processing essential functionalities such as login, course management, assignments, and AI-based services. The Data Layer is used for secure data storage and retrieval through the relational database system.

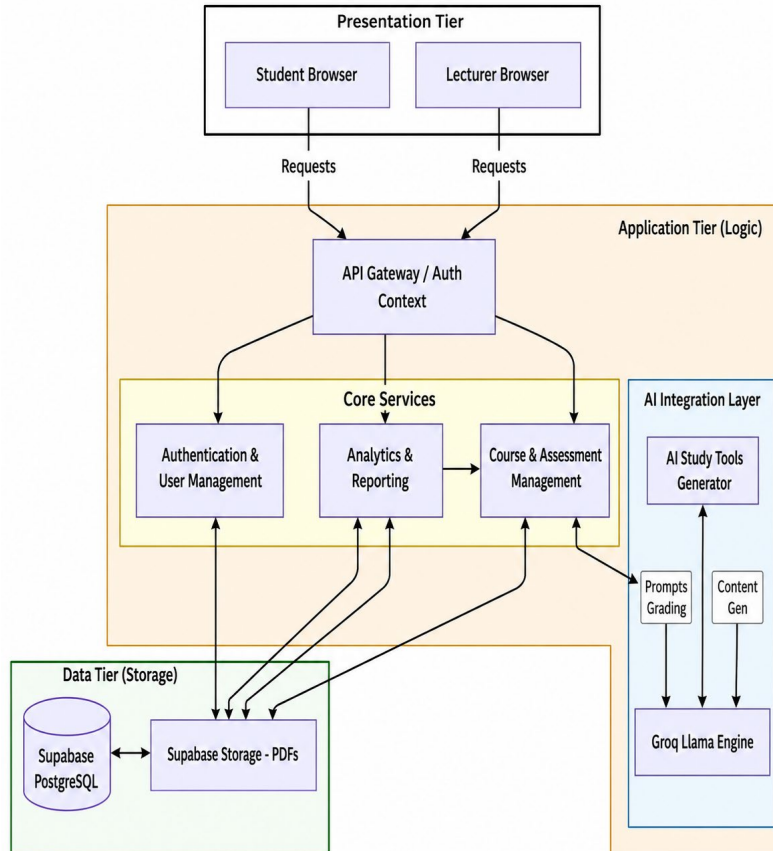


Fig.1 System Architecture Diagram of Edusync

B. System Workflow

The system workflow starts with user login and registration. After logging into the system, users are redirected to their respective dashboards according to their roles. Students can

view learning materials and assignments, while lecturers can grade assignments. AI questions and performance reports are created by the system for evaluation purposes. A role-based authorization system makes different features accessible to users according to their roles.

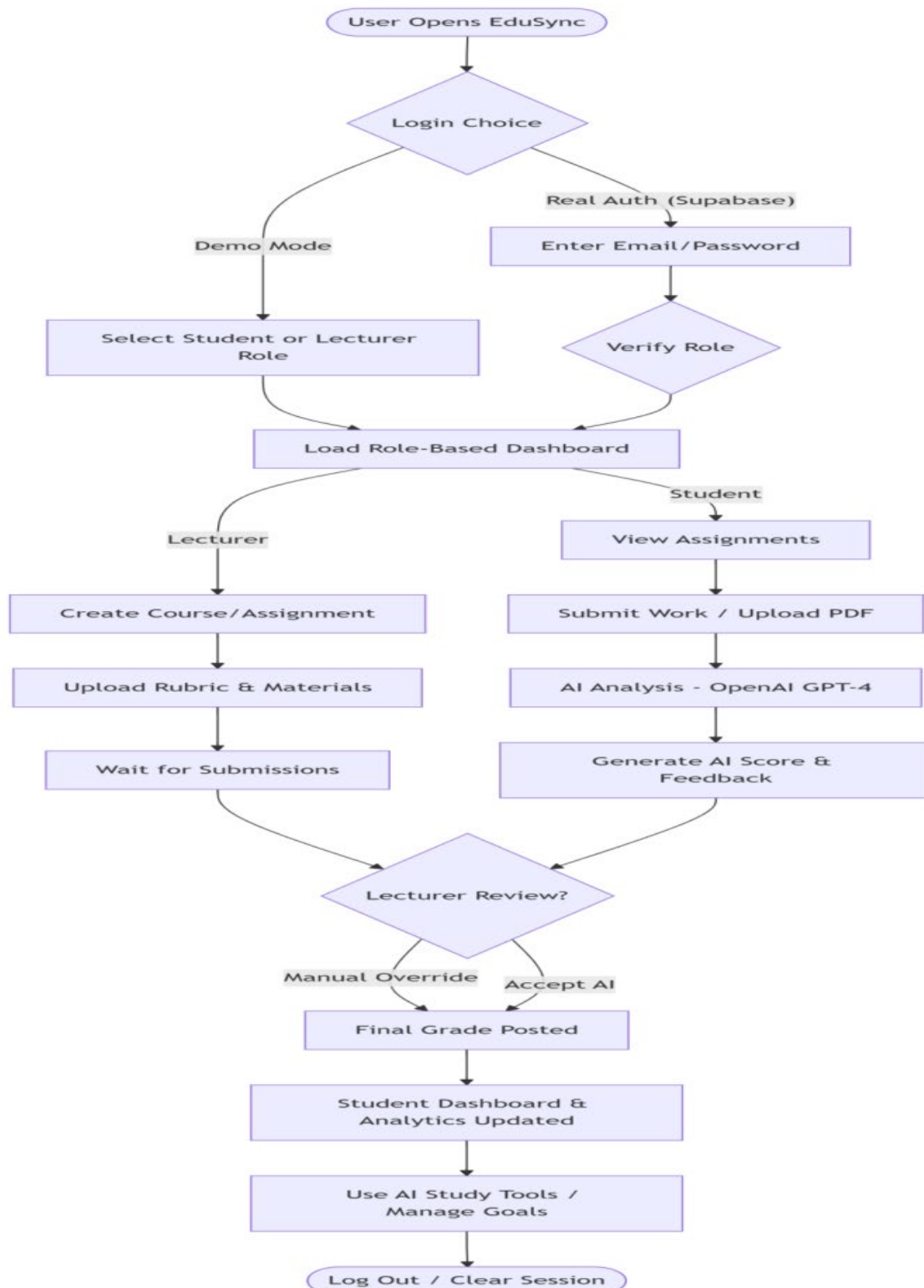


Fig.2 Workflow Summary Diagram of EduSync

C. Use Case and Sequence Modeling

The use case diagram demonstrates how interactions take place between students and lecturers within system components such as authentication, course management, and

feedback generation. Sequence diagrams explain the process of information transfer during critical activities such as assignment submissions, AI evaluation, and feedback transmission, from document upload to notification of the grade.

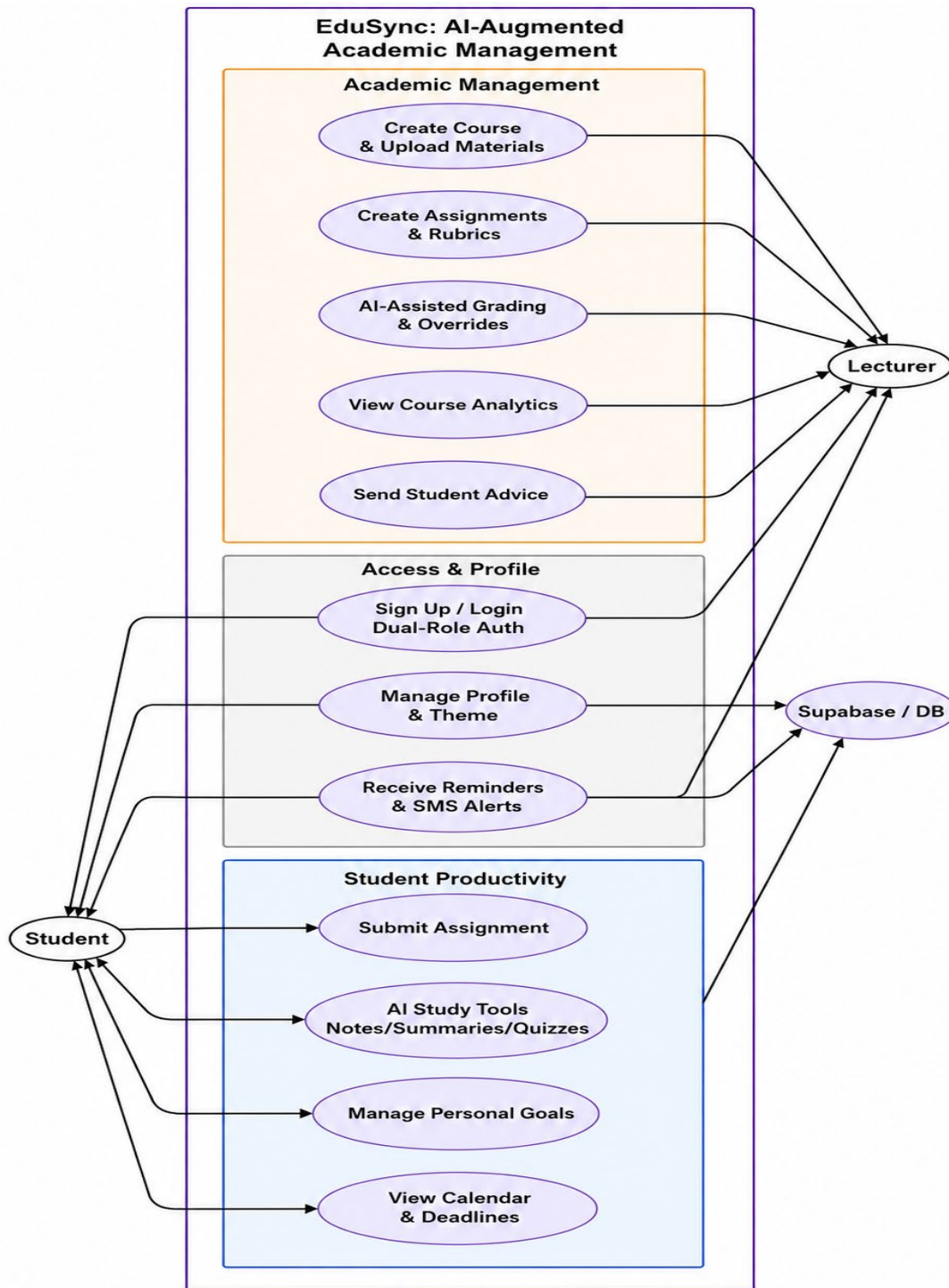


Fig.3 Use Case Diagram of EduSync

D. Entity Relationship Design

The Entity Relationship Diagram (ERD) demonstrates the relationships between the primary data in the system. One lecturer may be in charge of several courses, and each course

can have numerous assignments, whereas a student can upload several assignments. Each assignment is associated with one AI feedback record. In this way, redundancy is avoided and access to data is optimized.

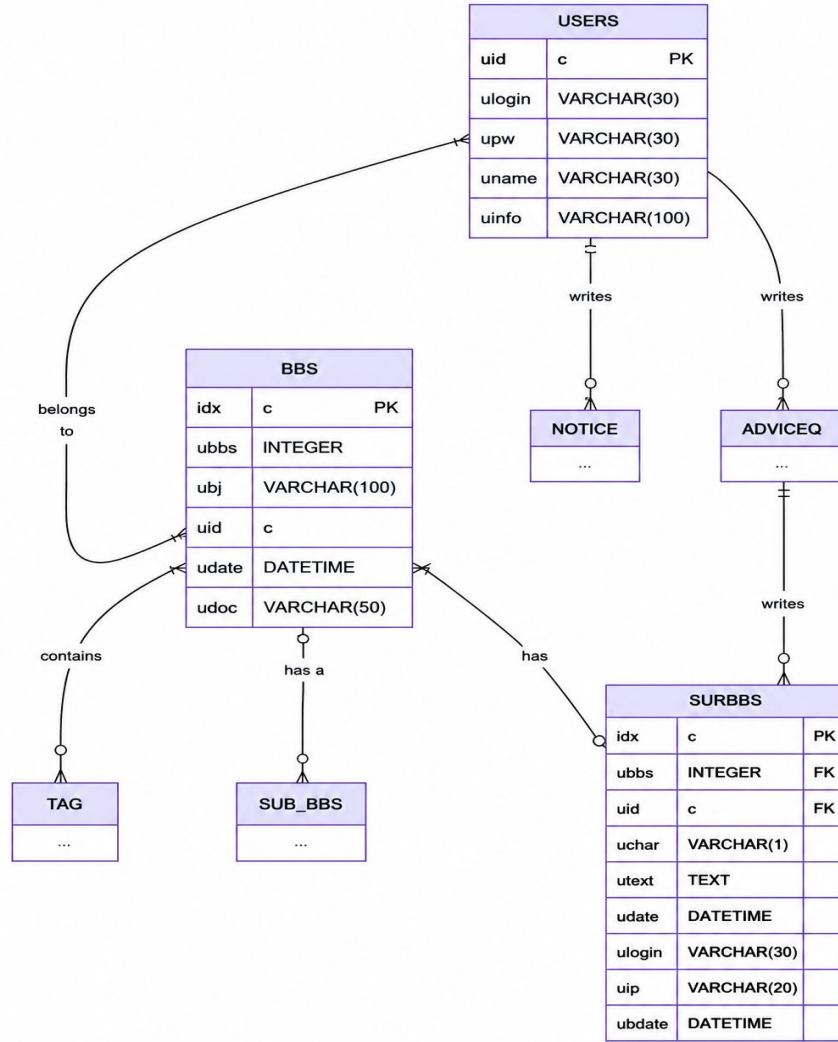


Fig.4 Entity Relationship Diagram of EduSync

E. User Stories

In early 2025, a requirements survey was conducted via Google Forms to obtain feedback from the potential user base

on the features they anticipated in the system. Data obtained through the survey became the basis for creating the user stories presented in [Table I](#).

TABLE I USER STORIES

As a	I want to	So that I can	Expected outcome
Student	Register and log in using my email	Access my courses securely	Successful authentication and access granted
Student	Submit assignments online	Meet deadlines conveniently	Assignment submitted and stored
Student	Receive AI-generated recommendations	Focus on weak topics	Personalized recommendations displayed
Lecturer	Grade submitted assignments	Monitor student progress	Grades stored and visible to students
Lecturer	Upload course materials	Easily manage content	Materials stored and accessible
Administrator	Manage user accounts	Maintain system integrity	Admin can add, edit, or remove users

F. Functional Requirements

TABLE II CORE FUNCTIONAL REQUIREMENTS OF EDUSYNC

ID	Requirement description	Module	Priority
FR001	System shall allow the admin to manage login, registration, and role selection for lecturers and students	Authentication	High
FR002	System shall grant role-specific secure dashboard access to all user types	Authentication	High
FR003	Lecturer can create, view, edit, and delete their own courses	Course management	High
FR006	Lecturer can create, view, edit, and delete assignments with due dates and grading rubrics	Assignment mgmt	High
FR007	Student can submit assignments and track individual submission status	Assignment mgmt	High
FR008	Lecturer has tools to grade assignments and manage a grading queue with AI suggestions	Assignment mgmt	High
FR013	Student can set and track individual academic goals with progress visualization	Goal tracking	Medium
FR015	System shall notify students of new grades and lecturers of new submissions	Notifications	Medium
FR017	Student has access to AI-powered study tools, including PDF summarization and note generation	AI study tools	Medium
FR022	Responsive design ensuring full functionality on student and lecturer mobile devices	Theme/UI	Medium

Functional requirements define actions needed to meet user requirements. Functional requirements of EduSync are presented in Table II.

G. Non-Functional Requirements

System attributes are determined primarily by performance, security, and usability. Specifically, all application functionality should work efficiently and quickly for each user, and the user experience needs to be secure for all users. All personal data will be encrypted using SSL/TLS. In addition, the application should operate during periods of high activity and scale with additional users and lecturers.

Finally, the application interface is designed with the comfort of both groups in mind [12].

H. Technology Stack

React 18 and TypeScript are used on the frontend to implement a component-based architecture for efficient development. In addition, Vite is used to speed up development processes, while Tailwind CSS and Shadcn/ui are used to design the interface. The Supabase platform is used to store all data in PostgreSQL, perform authentication procedures, and handle real-time events. AI functionality in the application is achieved via the GROK (Llama) API. This technology enables features including grading and feedback generation. All data is transferred via SSL/TLS.

TABLE III EDUSYNC TECHNOLOGY STACK

Category	Technology/tool	Purpose
Frontend	React 18 (TypeScript)	Component-based UI framework with type safety
Frontend	Vite	High-performance build tool and development server
Frontend	Tailwind CSS	Utility-first responsive UI styling
Backend	Supabase (PostgreSQL)	Managed relational database, authentication, real-time features
AI layer	GROK(Llama) API	Automated assessment generation, grading, and feedback
Auth	JWT / OAuth 2.0	Secure role-based access control
Testing	Vitest	Unit and component testing framework
Version control	GitHub	Version control, collaborative code review, project management

I. Safety and Ethical Considerations

There are four key guiding ethical principles for the system. First, student privacy is assured through role-based access control; therefore, only authorized users can access students' personal and academic details [18]. The second principle concerns fairness in AI scoring, achieved through constant

testing and the avoidance of bias to treat all groups of students equally [9]. Third, transparency is achieved by providing feedback that students understand, so they are aware of how results are calculated and are not dealing with black boxes [5]. Finally, human intervention is guaranteed, since any lecturer decision overrides any decision made by the AI system [20].

IV. IMPLEMENTATION

A. Development Methodology

The system development process was conducted according to the Incremental Software Development Model and consisted of eight phases, from basic functions such as user and course management to the creation of advanced study tools based on AI algorithms. Each new phase provided opportunities for improvement, as the model allowed changes to be made step-

by-step [12]. Each phase was tested before proceeding to the next stage.

B. System Requirements

The EduSync system is built on a fundamental structure that includes at least an Intel Core i3 processor, 4 GB of RAM (with 8 GB preferred), an internet connection, and a modern browser. Regarding software, it was developed using Node.js, Supabase for its backend infrastructure, and the GROK (Llama) API. Furthermore, it is fully compatible with Windows, macOS, and Linux operating systems.

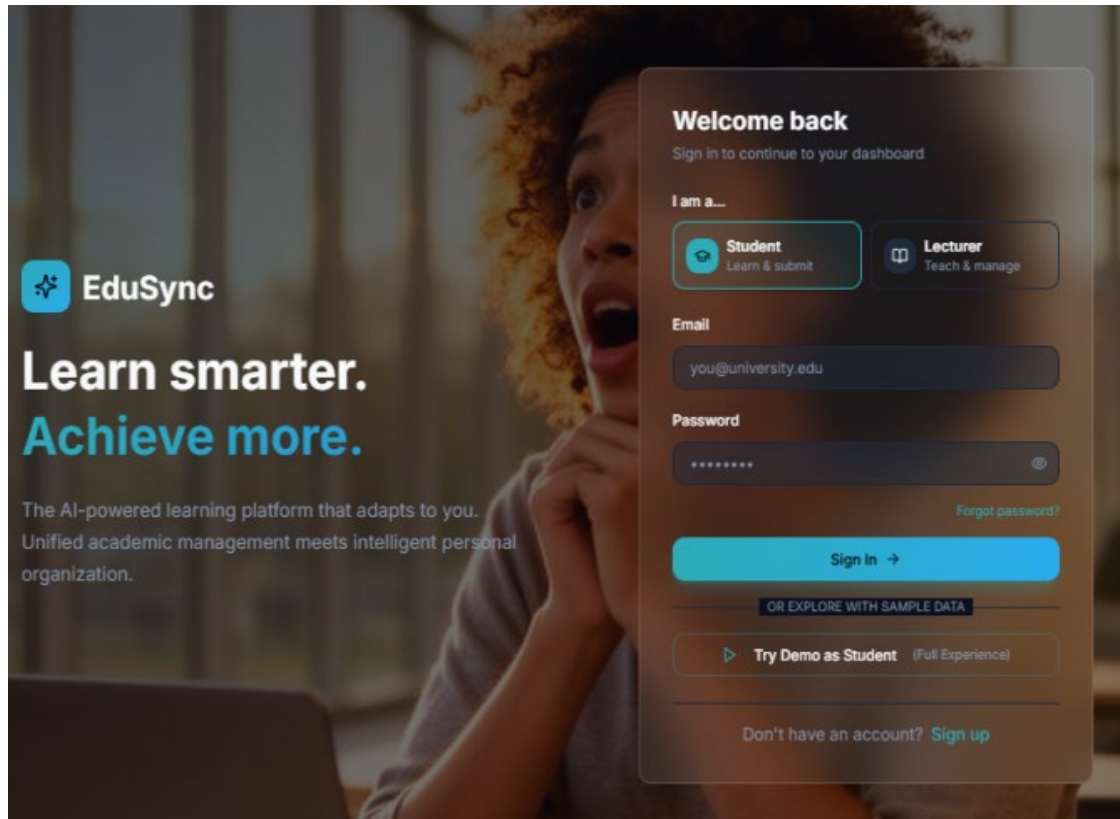


Fig.5 Authentication and Login Interface

C. Module Implementation

Five primary components form the EduSync system: the Authentication module, the Course Management module, the Assignment Management module, the AI Assessment Engine module, and the Student Life Management module. Each was developed independently and underwent extensive testing prior to the integration of all modules. Role-based access control (RBAC) is applied in the Authentication module, enabling the distinction among students, lecturers, and administrators [16]. CRUD operations for managing courses and course content are included in the Course Management module. Assignments are submitted and graded, and feedback is provided using artificial intelligence in the Assignment Management module. Lastly, the Student Life

Management module enables students to efficiently manage their lives outside class.

D. AI Assessment Engine

The AI Assessment Engine utilizes the GROK (Llama) API to help automate marking and provide instant feedback during objective tests. This module interacts with the AI through data transfer involving rubrics, submissions, and marking criteria, and then feeds the outcome through the lecturer's marking interface. Moreover, the AI Study Tools component adds more capabilities by allowing learners to submit documents in various file formats, including PDF, DOC, and PPT, and enabling the system to develop study guides and quizzes of varying lengths [7].

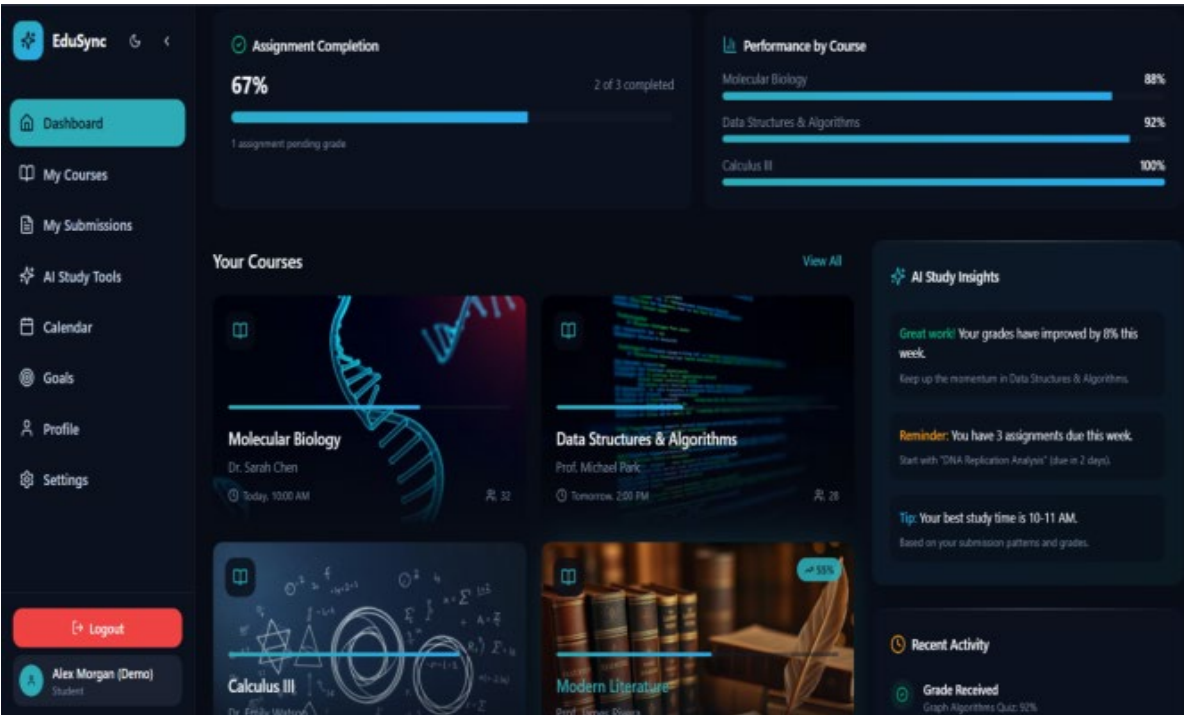


Fig.6 Student Dashboard Interface

Human-in-the-loop technology is applied in grading. Grades generated using AI algorithms are only presented as recommendations to the lecturer, who then makes changes as necessary before the grade is finally submitted in the student’s report card [20]. This system adheres to ethical practices outlined in the available literature [18].

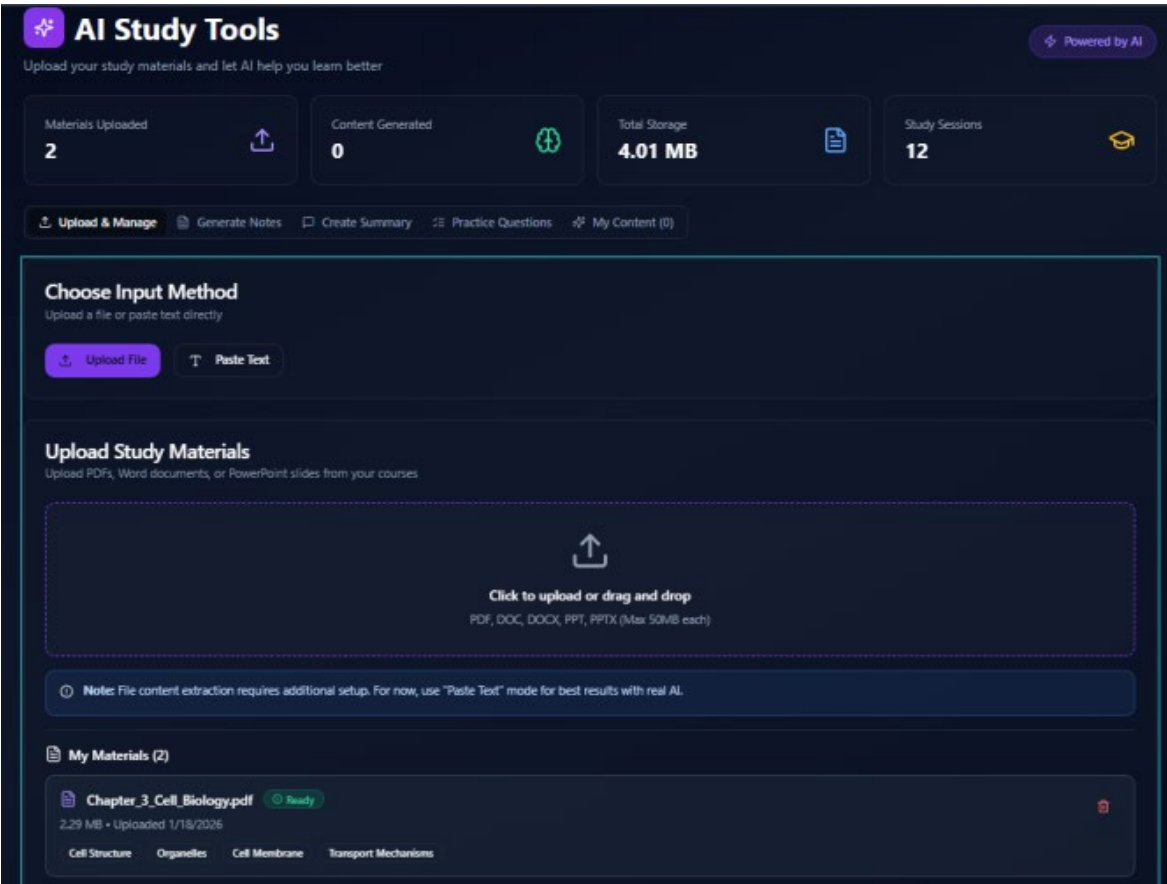


Fig.7 AI Study Tools Interface

E. System Interface

The system offers varying user interfaces based on users’ roles within the application. For students, the dashboard consolidates key data such as courses taken, assignments due, latest grades received, deadlines, and personal progress. This ensures that students can monitor all their academic engagements from one point. Lecturers are provided with an

interface that mainly deals with course management and tracking student performance. It features metrics such as total enrolled students, pending assignments, and performance analysis that can assist in pinpointing students requiring further assistance. The administrator interface facilitates management of the whole system. It enables the administrator to handle user accounts, assign roles, and configure system settings.

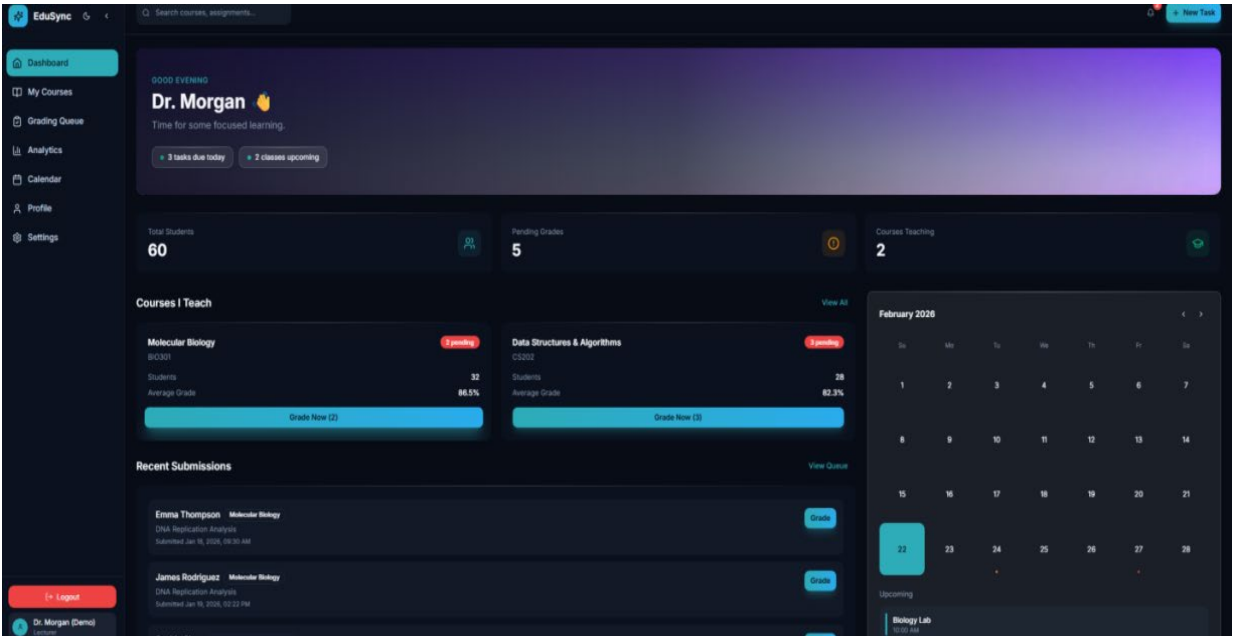


Fig.8 Lecturer Dashboard Interface

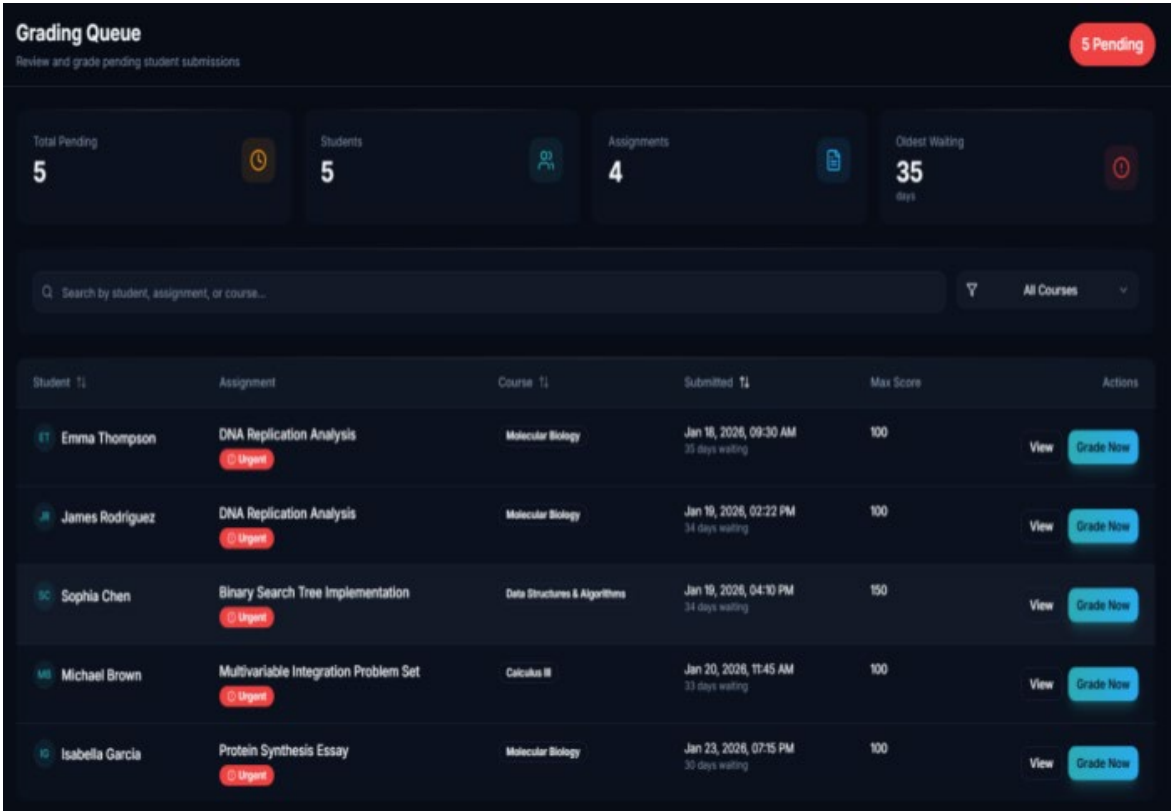


Fig.9 AI Grading Queue Interface

V. RESULTS AND DISCUSSION

A. Performance Evaluation

TABLE IV SYSTEM RESPONSE TIME EVALUATION

Operation	Observed response time
Login authentication	1–2 seconds
Dashboard loading	1–3 seconds
Assignment submission	< 2 seconds
Grade update reflection	Real-time after refresh
AI study tool response	3–5 seconds
Concurrent login simulation	Stable under moderate load

The assessment of the system’s performance included the analysis of its responsiveness, reliability, and behavior under heavy load. This assessment was carried out in the framework of the development process. The data related to the system’s performance are presented in Table IV. Efficient query management was achieved through better routing and the creation of optimized PostgreSQL queries. Database normalization ensured that there were no unnecessary data redundancies, thereby ensuring consistency. With primary-key indexing and role-based filtering, data access became faster, with fewer unnecessary database visits. Security testing revealed that the system effectively managed attempts at unauthorized access. Unauthorized users were redirected accordingly, as expected, and all tests were successful [16].

B. Functional Testing Results

Functional testing was conducted to ensure that the system satisfied all 22 stated requirements. The findings demonstrated that the major software functions operated as required in various sections of the application. Specifically, authentication functioned properly, with users authorized by role and each role able to execute its assigned tasks. Additionally, the test proved that course management functions, such as creating, reading, updating, and deleting courses, worked without glitches. The assignment submission process was successful, as students submitted their assignments while lecturers recorded their grades successfully. The system also facilitated grading by performing text analysis and providing feedback in line with the set criteria. Lastly, other artificial intelligence features for PDF summarization and practice question generation also produced results as expected [4].

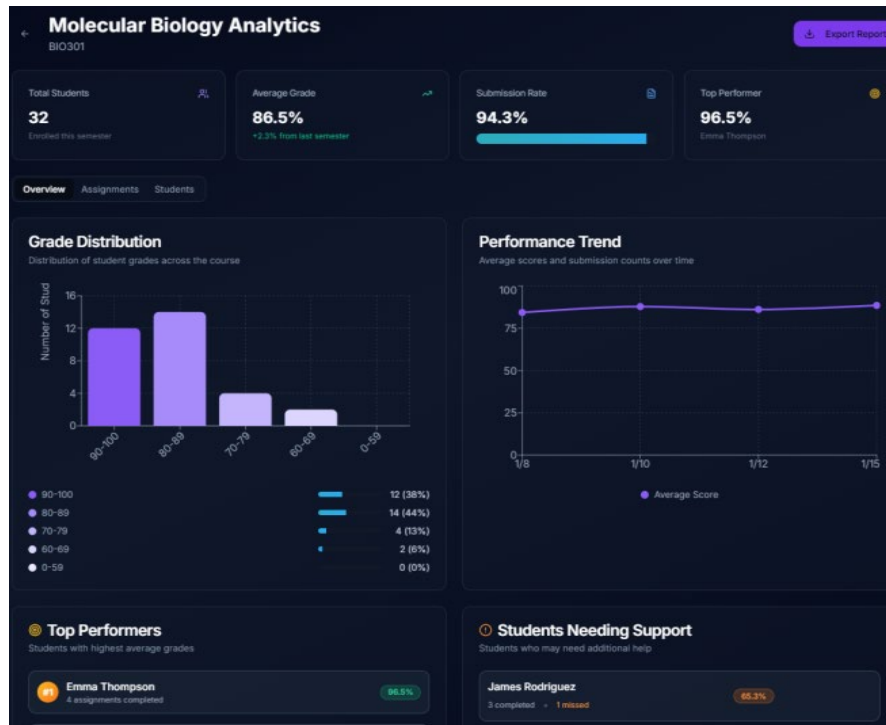


Fig.10 Course Analytics Dashboard

C. Comparison with Existing Systems

EduSync was evaluated against various available technologies to determine its effectiveness. Compared with traditional academic management solutions, EduSync is a superior option because it has several advantages. Namely, this technology keeps all information within one central database, automates grade calculation, and allows real-time dashboard updates. This significantly reduces the possibility of errors and increases process efficiency [3]. Compared with popular e-learning platforms such as Moodle and Blackboard, EduSync is a lighter solution that works well in resource-constrained environments. EduSync includes role-based interfaces designed specifically to facilitate interaction between students and instructors [21]. Unlike individual applications designed exclusively for grading purposes, EduSync consolidates a variety of functions into a single solution. This software incorporates various processes, including grading assignments, managing coursework and courses, and tracking performance [12].

D. System Limitations

Some limitations were noted during the design and testing process of EduSync. First, AI recommendations for personalized learning paths are still to be developed. Such an improvement would contribute significantly to students' interaction with the website. Also, scaling EduSync to include additional users requires more research into better server configurations and changes in database settings. Such issues were not considered within the framework of the current work. Being web-based, EduSync relies on constant Internet access. However, this issue may arise in some areas of Nigeria because Internet accessibility is not very high [15]. The next limitation of the system is the absence of a mobile application; the integration of other systems, such as ERP systems for admission and financial management, has not been considered either.

VI. CONCLUSION

In conclusion, the requirements for EduSync have been successfully met in the present study. The findings presented above show that including an AI element in one integrated learning environment significantly simplifies activities such as assessment for lecturers while helping students monitor their goals and receive reminders to complete certain activities on time [16]. EduSync was developed using React 18, TypeScript, Supabase, and the GROK (Llama) API. Therefore, the combination of these technologies makes it possible to develop a functional and effective platform for use among students and lecturers in Nigerian higher institutions. As noted previously, several aspects require improvement. In particular, the development of a mobile version of the platform would increase its availability. Predictive features aimed at identifying students who may fail to achieve their objectives during the early stages of a semester could serve as another improvement [23]. It would also be beneficial to introduce SMS reminders for students

with poor internet connectivity, for example, through the use of Twilio. Finally, grading improvements, including a mechanism for identifying potential biases in the criteria, can be made.

Declaration of Conflicting Interests

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Use of Artificial Intelligence (AI)-Assisted Technology for Manuscript Preparation

The authors confirm that no AI-assisted technologies were used in the preparation or writing of the manuscript, and no images were altered using AI.

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