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Design and Simulation of Computerized Student Information Tracking System

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Abstract

A database management system (DBMS) with a feature of role based access control (RBAC) and record tracking system was developed and simulated as a Student Information Tracking Systems (SITS). The main objective of developing and designing the SITS was for computerization of personal and academic records of students from enrolment to graduation in relative to their academic activities in higher institutions. The system was developed using a three-tier architecture comprising a user-friendly interface, robust backend logic, and a structured database for data integrity. Functional modules such as login authentication, student registration, grade upload, attendance tracking, and PDF record generation were simulated to demonstrate feasibility and efficiency. The hardware material utilized was a laptop with Intel Corei5 2.4GHz speed processor, 8GB memory and 500GB hard disk storage drive. The utilized software components are PHP, Javascript, HTML/CSS and MySQL. In addition, the simulation of the SITS was carried using MATLAB on the aforementioned laptop with the aid of necessary APIs and aforementioned software above for carried out the necessary performance tests. The simulation results confirmed that the system provided accurate data management, reduced redundancy, and improved accessibility across multiple roles, including administrators, lecturers, and students. Security features such as role-based access and validation mechanisms were incorporated to ensure privacy and compliance with data protection standards. The average response of the login user interface was 1.3 seconds. The average response for generating report was obtained as 0.9 seconds. The obtained data were 100 percent accurate with an average of 150 concurrent users on the systems at an average of running uptime of 99.7 percent. The successful deployment of the system, including the use of logins, role-based dashboards, access to student profiles, upload grades, attendance tracking, and the generation of PDF records testify to the fact that the system is ready to be implemented in real life. Its simplified user interfaces and simplified workflow enhanced its practical usage. Therefore, it can be adopted by both technical and non-technical users. Finally, it is a viable tool to be adopted by tertiary institutions where digital transformation of academic management continues to be a developing demand.

Keywords: Attendance, Database, Simulation, Student Information System, Transparency

1.0 INTRODUCTION

The size and sophistication of educational institutions are growing, and the amount of student data is also growing exponentially, which prompts the need to implement computerized tracking tools to ensure better accuracy, consistency, security, and timely access to information (Ahmed et al.,2022; Archambault, 2021). The Student Information Tracking Systems (SITS) are designed to control, arrange, and track the academic and administrative pathways of pupils in real time utilizing a developed digital framework. Such systems have more advanced feature which lets the tracking of course registration, constant assessment, exam scores, grade, attendance, disciplinary proceedings, tuition, and graduation status, all in one database. Such systems design, implementation, and simulation are thus critical in making sure that learning institutions have deployable, scalable, and secure tools that can help improve student data management, trim administrative processes, and lastly, improve institutional performance and services delivery (Afolabi et al., 2021; Dayanghirang et al., 2022). The idea of having a Student Information Tracking System (SITS) is not actually a new concept; yet, with the recent improvement in computer engineering, database management, and information systems design various more integrated more automated and easier to use models have been developed to handle numerous student related operations at the same time. Current SITS models are currently taking advantage of cloud computing, artificial intelligence, and encrypted database features to provide real-time accessibility, scaling, and data protection. As the numbers of students swell and the complexity of academic programmes in higher institutions of learning intensifies, computerised systems bring an administrator and educators a centralised platform to automate, stream-line reporting, facilitate data access, and make informed decision-making that ultimately lead to an increase in productivity and service delivery of the institutions (Alabi et al., 2021; Kustitskaya et al., 2023; Nwankwo et al., 2023 Nwankwo et al., 2023; Okeke et al., 2022).

System design, which has the aspect of simulation, allows researchers and developers to simulate and study the expected behaviour of a student information system before it is physically implemented into a real-world setting. Simulation allows developers to model the operational conditions, evaluate performance at different workloads, and study the system behaviour in different user conditions. It is a proactive method that does not only improve the quality of designs but also contributes to effective use of institutional resources and infrastructure (Olajide et al., 2023). As follow up to highlights of Uwadia & Ogunlade 2020, a modelled simulation system for SITS is an essential research area which the authors of this paper approached with reported solution. This proactive practice will reduce implementation risks, in addition to making the final system robust, secure, and optimised to achieve institutional objectives in a way that is effective (González-Nucamendi et al., 2023).

Alongside administrative advantages, the computerized tracking provides the students with clear access to their academic history, grades, and status on the progression, thus, creating accountability, self-control, and confidence in the management system of the institution (Uche et al., 2022). Moreover, in the wake of the existing data protection laws at the institutional, national, and international level, including Nigeria Data Protection Act and the General Data Protection Regulation (GDPR), which underscores various issues of user privacy, consent management, and accountability in processing student data (Afiqah et al., 2025; Daoultzoglou, 2023; Salami et al., 2021). Besides making administration efficient, strategic student information tracking systems (SITS) implementation is critical towards supporting data-driven policy development and institutional decision-making. Finally, the transformation of manual student record keeping to SITS will enable educational leaders to acquire more effective, accurate, and sustainable policy-making, which will promote institutional development and academic achievement (Bello et al., 2023; Okon et al., 2023).

The use of computerized student information tracking system is a revolutionary solution as all the records are incorporated in a central platform where redundancy is avoided in addition to simplification of work as well as the accuracy, consistency and up-to-date information. These systems may also be configured with automated backup and auditing facilities in order to maintain the integrity of the data as time goes by. In addition, the incorporation of user role management system and access control system enables institutions to establish the level of permissions of students, lecturers and administrators so that the sensitive information can only be accessed by the authorized individuals. Such a multi-tiered solution not only helps to increase the level of data security but also leads to greater accountability and transparency in the work of institutions (Ibrahim et al., 2021; Kaindaneh, 2024; Silwamba, 2025).

The process of simulation in system design is also a crucial stage where the developer gets to detect, analyse and fix the design weaknesses or any inefficiency in the design prior to the physical implementation of the system. Besides, simulation offers invaluable information on the system performance measures, such as data processing time, transaction throughput, latency, and user response rate, and thus can help in meeting the expectation of the services delivered by the system. Also, by using strong simulation packages like MATLAB, Simulink and Java based development systems, one can easily prototype, simulate and refine system components easily. The time and cost of development are minimized, and this testing process ensures the final implementation is reliable, flexible and able to accommodate the complex data management requirements of contemporary learning institutions (Vincent et al., 2023). Hence, the concepts of analytics integrated into the student information system turn it into a resource of data availability rather than a strategic decision-making instrument and the key to academic efficiency, responsibility, and overall institutional development (Muleya et al., 2024). This development process guarantees that the system is not only technical but user-friendly, which improves its chances of being adopted and making it successfully operate in educational institutions in the long-term (Eze et al., 2020). The flexibility and scalability of SITS play a crucial role in matching the features of the systems to the institutional development, policy changes, and evolving administrative requirements to the education industry (Hoek et al., 2024; Ogunlade et al., 2022).

2.0 LITERATURE REVIEW

Student Information Systems (SIS) or Student Information Tracking Systems (SITS) represent holistic, integrated digital systems that are able to effectively record, store, retrieve and update all student-related information in academic institutions. These systems are comprehensive in nature in their functions however they include registering students, tracking fees, enrollment in courses, monitoring attendance, processing grades and the graduation status. With the growing student enrolment and curriculum proliferation, the tasks of student information tracking become more complicated, and the implementation of high-quality, user-friendly, and scalable information tracking systems becomes helpful and even crucial to the effective functioning of a tertiary institution and its long-term educational progress (Kirilov, 2021). The modern systems are cloud-native, compatible with remote learning processes, and can be linked with national education and accreditation databases, which has become an immense improvement over their traditional counterparts (Falolo et al., 2022; Ishaq et al., 2023).

Computerized systems are a very important aspect of a design and simulation process to ensure that a proposed application is reviewed to ensure that it satisfies its functional and non-functional requirements prior to complete deployment. By simulating, developers can test the logic of the system, test the flaw of the design, test the performance benchmarks and refine the component of operations to attain optimum efficiency. In the case of educational institutions with small budgets and lack of technical possibilities, simulation is a cost-effective and time-saving approach to ensuring the reliability of software, its usability, and performance consistency prior to its use in the real environment (Chakraborty et al., 2024; Farag, 2023). Simulation enables the developers to predict the behaviour of the system in different conditions, determine possible bottlenecks in data processing or network communication, and optimize the system architecture to achieve high performance before actual deployment (Muslim, 2024; Rashid, 2024).

Another critical aspect of SIS is the use of simulation methods to guarantee the best level of system reliability, performance and scalability before it is implemented in a real-world scenario. The traditional manual testing is usually time-consuming, labour-intensive and finite in its scope; simulation allows developers to build virtual models which recreate the behaviour of the system in different operating conditions. It is therefore possible to test the performance of a system under stressors such as the number of users who are actively logged on during course registration periods, running of heavy database queries when compiling results, or all the students, lecturers, and administrators simultaneously. These virtual test environments enable identification of possible bottlenecks in processing speed, memory usage, query optimisation and network latency - aspects that are important in the stability of the system. According to researchers, simulation significantly lowers the economic and time costs of the repetitive redesign of the system through its use of successive testing and performance tuning prior to the deployment (Kotresh et al., 2024). This benefit is especially relevant to the Nigerian setting, in which numerous institutions of higher learning are faced by budgetary constraints, shortage of technical staff, and lack of facilities, and physical system trials are unfeasible because of this. In addition, simulation assists in prototyping and visualisation, which give a stakeholder real-world previews of system functionality such as interface development, data flow, access control layers and user interaction pathways. This participatory arrangement helps to align the user expectations and technical requirements and thus minimises any post-deployment bugs and user acceptance once the system has been installed (Kotresh et al., 2024; Rashid, 2024).

System development Simulation is used as a validation and a risk-reduction tool: simulation tools used in academic projects to model user concurrency, database-query loads, and network latency had the ability to find performance bottlenecks and optimise indexing, caching and query patterns before implementation. In these simulated environments, developers are able to recreate intricate user behaviour and stress individual vital components of the system and also stress-test the architecture, without affecting live infrastructure, thereby creating a more trustworthy and scaled architecture. Empirical studies in engineering education support the importance of simulation in safe, cost-efficient testing in which production data and uptime cannot be sacrificed; simulation allows evaluation of system logic to be repeated and helps the team to compare the designs of the alternative designs before implementation (Luo, 2024; Lam, 2024). Additionally, simulation is used to carry out repeatable experiments of system responsiveness in a controlled condition to ensure that the latency and throughput do not exceed acceptable levels, and resource utilisation is within acceptable limits. These activities directly overlay onto a student information system that will be required to perform at its highest registration point or result-release points when thousands of requests can take place in various simultaneous processes and require a robust and optimized backend that can ensure operational stability (Negahban, 2024; Rahman et al., 2023).

Recent studies have shown that combining MATLAB or other quantitative systems with web-stack load-testing systems like Apache JMeter, Gatling, or Locust can provide a very accurate response-time curves and can allow researchers to produce reproducible, data-driven performance reports, which can be used in academic analysis. The combination of theoretical analysis and validation of the real system makes this integrated approach fill the gap between the theoretical analysis and validation of the real system by enabling the developers to visualise the latency distributions, find the saturation points and relate the database or network performance to the simulated user concurrency. The rich statistical and modelling features of MATLAB can be used to analyse the performance data collected at a fine level; a developer can fit mathematical models to determine how the system can scale on different loads, whether it contains bottlenecks and the extent of the realisation of optimisation methods. Meanwhile, load-testing tools like JMeter can recreate the behaviour of concurrent users, HTTP calls and API interactions that are highly similar to the behaviours of real students on web-based applications, and which offer realistic understanding of throughput, as well as response consistency. Surveys mapping simulation results to optimisation actions like restructuring inefficient query plans, or adding or refining database indices, or caching a static resource or real-time queueing mechanisms on heavy report-generation tasks were reported to have significantly reduced median and tail latencies. These reduction of latencies are not by any means just incremental but radical, so that the system stays stable and responsive even when the institutions are at their peak moments, like the mass grade releases, course registration deadlines or even when the exam results are being published. Besides, the repeatability of these simulations makes them useful in benchmarking performance in the development cycles, academic grading rubrics, and best practices in teaching software engineering. Finally, the integration of these research methodologies contributes to simulated testing as the key to credible system performance testing and optimisation in the contemporary academic software setup (Aldabagh, 2024; Campos et al., 2020; Reisman, 2021).

Multiple empirically deployed systems integrate RFID-based attendance capture systems with embedded web portals that real-time synchronise the data collected with the Student Information System (SIS) of the institution to create an effective feedback mechanism between physical access points and digital records. Hybrid systems, reported in many conference papers, prototype demonstrations, and institutional pilots, can be used as a learning experience to developers and scholars to develop a model that can capture the hardware-level capture process, as well as the overall end-to-end data-handling pipeline. Under such patterns, RFID readers at the classroom doors receive the student tag data when they enter the classroom, which is then sent with the attendance event over secured communication channels such as Wi-Fi or Ethernet to a central server. The SIS, in its turn, works with these records, changes attendance tables, cross-checks student identifiers and initiates downstream analytics, like trend visualisation or absence notification. This automation saves a lot of administrative weight; it increases the data reliability, auditability, and timeliness. The body of literature also provides full resources, such as open-access test datasets, event-sequencing patterns and time-stamped logs that can be used by system designers to recreate scenarios involving attendance in simulation environments. This type of datasets is also specifically useful in testing the correctness of a system in constrained or dynamic situations, e.g. overlapping class times, simultaneous detections of multiple tags, or slow network response. Using these event patterns to simulate makes it possible to verify data-integrity rules, i.e. that each RFID scan is properly logged, timed and connected to the correct student and course instance. The concurrency of the systems has also been used by researchers to test how well simulations manage these systems and how quickly the analytics dashboards that are used by administrators update. This type of end-to-end performance testing is essential in situations involving the expansion of attendance systems to large institutions with thousands of students and numerous simultaneous access points. Therefore, not only hybrid RFID-SIS architectures demonstrate the synergy between hardware automation and cloud-based information management, but also offer a reproducible model to academic and enterprise-level initiatives in an attempt to certify accuracy, speed, and reliability of automated attendance systems (Campos et al., 2025; Gonzalez-Nucamendi et al., 2023; Sharma et al., 2025).

Finally, these proactive security exercises transform cybersecurity into a reactive, post-incident endeavor into an endless loop of learning, adjusting, and enhancing to increase architectural tenacity and prevent academic integrity and trust among stakeholders (Wired, 2023). In the end, such a proactive attitude toward usability and human-centered design guarantees a smoother implementation, increased adoption rates, and decreased resistance to the changes among the staff and students, which makes it possible to get the full operational and pedagogical benefit of the SIS technologies in institutions (Vakaliuk et al., 2020).

Nevertheless, the current process of digitalization in the Nigerian education sector provides a positive perspective, which will promptly trigger the increase in efficiency and accountability through the long-term investment in the design, simulation, and implementation of computerized student information tracking systems that will guarantee institutional sustainability in the digital age (Adebayo et al., 2020; Alhadlaq, 2023; John et al., 2024). With a systematic approach to addressing them, Nigerian colleges will be in a position to maximize the transformative power of computerised student tracking systems, which will enhance their data integrity, efficiency in operations, transparency, and the overall academic management (Amaonye et al., 2023; Chukwuemeka et al., 2024). Altogether, analytics makes the contemporary SIS a dynamic institution strategy, performance measurement, and student success platform instead of a system of stationary data storage (Zaineldeen, and Hongbo, 2021). Finally, elementary usability will always define the strength of a student information system in the sense that it is not only the strength of technical abilities of a system that defines how user groups, such as administrators, lecturers and students, can comfortably interact with it to achieve their goals; both academic and administrative in nature (Ajibare et al., 2025; Hasman et al., 2022).

3.0 METHODOLOGY

3.1 Design Methodology

System Development Life Cycle (SDLC) Model.

For the design of the desired SITSt, the Waterfall Model was adopted to be the System Development Life Cycle (SDLC) method due to its very structured and well-organized and disciplined nature that would be a well-suited fit within the context of the academic design, analysis, and simulation. Figure 3.1 depicts the Waterfall Model with its well organised logical structure. Its phases includes requirements gathering where all the system requirements and functional specification are carefully identified and recorded; system design where architectural layout, data flow charts, component interfaces and interface planning are undertaken; implementation where the system design is translated into executable modules using programming language or simulation models; simulation and testing where the developed system is thoroughly tested to ensure functionality, accuracy and performance meet the set requirements; and finally documentation where all the findings, methodologies and outcomes are recorded to be used in future reference, analysis and improvement. The sequential character of the Waterfall Model means that one step will be based on validated outputs of the previous step and as such any risks of rework and ambiguity in requirements are prevented. This method is particularly beneficial when doing an academic research or a system design project where the goals, constraints and the anticipated results are well known beforehand and where varying requirements are of little consequence. In addition to that, its focus on detailed documentation and traceability makes it very adaptable to scholarly settings which require transparency, repeatability and in-depth reporting of the development process.

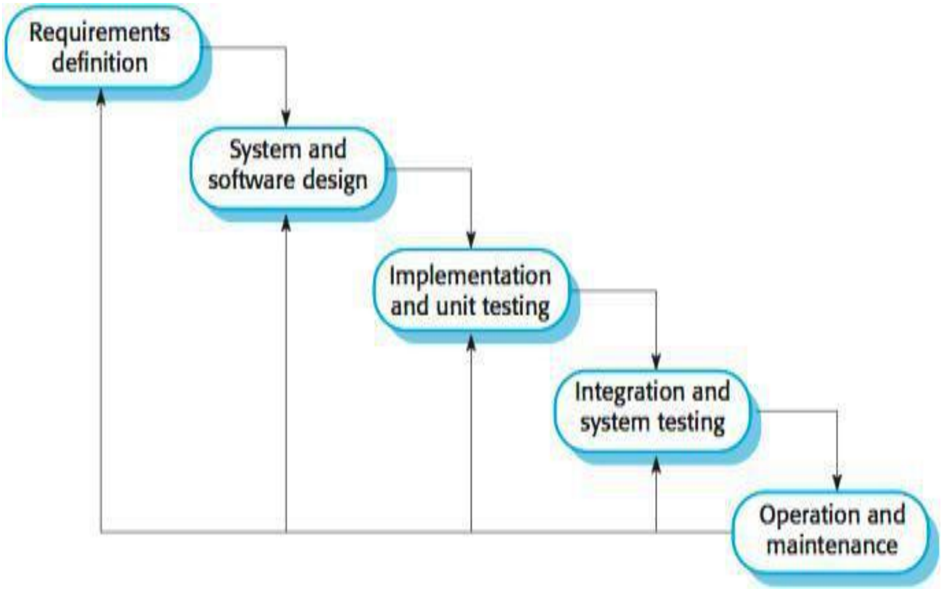


Figure 3.1: Phases in the Waterfall Method (Sommerville, 2011)

3.1.1 System Analysis

A comprehensive review of available systems showed that most of the educational institutions are still using spreadsheet-based or partially computerized systems to handle the data on students. Although these conventional approaches enable the simplest methods of record keeping, it is vulnerable to various critical limitations, such as vulnerability to security attacks such as unauthorised access and accidental data loss; inconsistency and redundancy of record keeping due to manual data entry and storage across multiple files, poor scalability because of the lack of real time data synchronization, automated reporting tools and slowness in administrative decision making. All these challenges hinder the efficiency, reliability and responsiveness of the administrative operations in academics.

To alleviate these shortcomings, the proposed system incorporates a centralized and database-based design that ensures that the data integrity, data consistency, and data accessibility through a single platform. The system will also have a secure login and authentication system to protect sensitive academic and personal records and provide a real-time access to data to provide timely updates, monitoring and reporting. Additionally, it facilitates role-based functionality where particular permissions and areas of operations are allocated to particular categories of user groups including administrators, lecturers and students to increase accountability, improve working processes and deter unauthorized practices. The use-case analysis was done in detail to identify the main system actors and their interactions in a systematic manner. The administrator controls user management, system configuration and report generation, the lecturer controls academic records, assessments, student evaluations whereas the student uses the system to access personal information, course registration, and performance data. This organized study, not only made the requirements of the user clear but also informed the functional and non-functional design of the system to make it robust, secure, and scalable based on the institutional requirements.

Figure 3.2 displays the data flow diagram for the developed model and simulated system. It comprises of the following key components:

i. **Admin**: Add/edit/delete student records, generate reports, manage users
ii. **Student**: View profile, grades, and attendance
iii. **Lecturer**: Upload grades, mark attendance

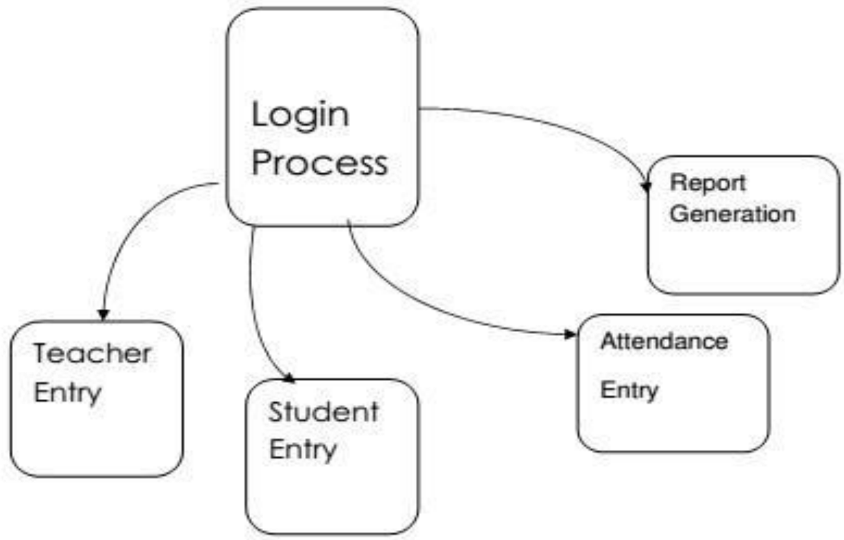


Figure 3.2: Data flow diagram for the Attendance System

3.1.1.1 Login Page

The login interface is the main portal to the computerized system of student information tracking and it was carefully designed in order to be easily accessible, clear and functional to all the identified user groups, which include: administrator, lecturer, and student. The page layout is based on a role-sensitive authentication system where each user is asked to use his or her registered username and password after which he or she selects the right role which is in the format of a well-defined dropdown menu. This role based difference is necessary in establishing the degree of access and specific modules that each user may be able to interact with upon authentication. The design is minimalistic but professional with the use of clear text boxes, clear hints indicating places, and a clearly visible button on a page marked with the word, Login to encourage simple communication. The interface is also designed with principles of responsive design giving it smooth adjustability with different screen sizes making it work well in desktop, tablet and mobile devices.

3.1.1.2 Admin Dashboard

Upon successful log-in by the administrator, he/she is redirected to the admin dashboard and this is the main administrative control center of the institution, data coordination, and system management and control. This dashboard has been carefully crafted to have a full but easy to use interface that integrates all the administrative functions into one and easily accessible workspace. With this panel, the administrator is able to effectively handle the information of students by adding new students, typing their key information; full name, matriculation number, department, faculty and academic level. Besides registration, the administrator is also able to carry out important data maintenance procedures such as editing, updating or deleting the student records to ensure that all the information stored is precise, up-to-date and in line with the requirements of the institutions. Another inseparable part of the dashboard is the course management module which offers the option to add, update or delete the course records and assign the appropriate attributes that include course names, course codes, credits and departmental affiliations. This centralized form of management makes the administrative processes easy and ensures that a minimum of redundancy is minimized and also data reliability is improved throughout the system.

In addition to data management, the admin dashboard will also include strong analytical and reporting features that will turn stored data into valuable information to support decision-making in the institution. To measure departmental performance and track the overall academic trends, administrators can automatically produce academic performance reports, grade distribution charts and attendance summaries. These reports are structured in a way that is easy to understand and can also be exported or even shared with other institutional units when necessary. The user interface of the dashboard was responsive and user friendly with structured menus, quick-access buttons and form-based input fields which make navigating the dashboard easy and lowers the learning curves among the users. Notably, the design was tested and simulated on mobile devices such as smartphones and tablets to ensure that it is adaptable in practical situations of use. This makes it easy to allow the administrators to carry out management activities and retrieve institutional data simultaneously stronger and more decisive of the system being practical, efficient and in tandem with the contemporary digital administration trends.

3.1.1.3 Lecturer Panel

The lecturer panel is explicitly designed to allow academic staffs to perform their administrative tasks connected with teaching at the push of a button. The first operational module that we can have here is the grade upload which allows the lecturers to key in the matric numbers of the students, choose the appropriate course and upload the grades obtained. All the entries are formatted and graded and then added to the database. The attendance marking interface is the second important module. This section contains a table that has five columns (Serial Number (S/N), Matric No, Course, Attendance, and Status). The initial column has the numbers between 1 and 10. Ten students with matric numbers that fall between the range of H/CTE/23/0765 to H/CTE/23/0777 (except 0773 and 0775) are listed in the second column. All the entries fall under the course column which is CTE425. The options include Present or Absent, which will automatically fill in the attendance column and will be chosen by the lecturer relying on his/her observation in the classroom. As an example, five pupils can be denoted Present, and the others as Absent, and it is in accordance with the real classroom attendance conditions. The third aspect of the lecturer panel is the course list access feature which shows all the courses that are assigned to the logged-in lecturer, namely CTE301, CTE325 and CTE425. This capability eases the process of workload management and helps to avoid the unauthorized entry of grades when it comes to courses that are not allocated. The designing of the panel was made simple and was simulated in Samsung Android UI that could be accessed and easily interacted on mobile platforms.

3.1.1.4 Student Portal

The student portal is a secure and individualized portal that has been used to provide the student with easy access to their academic and personal records in the computerized information tracking system. After a successful log in, students will see a profile page that contains the important personal information about them including name, matriculation number, the department where the student belongs, date of birth, email address and phone number. The details are mostly to the read only category so that the students cannot make any changes to vital academic identifiers or institutional data, but some permitted changes like changes in contact information can be requested and approved via the administrator interface to prevent data corruption. The portal has been designed to be user-friendly and easy to navigate through with clearly defined tabs and menus, which help students move with ease to various functions areas of the portal. The general design approach focuses on the simplicity, responsiveness, and mobile-friendliness that make sure that students can get their information any time and any place without any technical limitations.

In addition to personal data management, the portal will provide the students with real-time access to their academic records, and this will act as a transparent channel through which performance monitoring and academic responsibility will be monitored. In the academic modules, students will be able to see their semester-by-semester performance including the course by course in the form of detailed grade report with the course title, course code, course units and the related letter grade. This allows the students to monitor their academic performance over time and determine their strong and weak points. The portal also has attendance monitoring, which shows number of sessions conducted, number of sessions attended and percentage of attendance of individual course which promotes consistency and inculcates academic discipline. In order to add even more functionality, students can also produce and distribute their academic summaries and performance reports in professionally formatted PDF files; this is achieved through a downloadable records feature. Such documents may be official transcripts, progress reports or evidence of study, which may be submitted to the administration, scholarship applications, or outside examination. Altogether, the student portal is the representation of efficiency, transparency, and accessibility which is relevant to the contemporary scholarly information management systems that strive to empower students based on self-service digital platforms.

3.2 Selection Materials

The success of computerized student information tracking system design and simulation largely relies on careful choice of materials, including hardware, software and developing environment. All materials used were selected in accordance with their level of suitability, availability, compatibility, and the application to the system. The subsections below give the major materials to be used in this project.

3.2.1 Hardware Requirements

This project involved the simulation and design phase which demanded the use of a personal computer that was up to an acceptable standard to undertake database operations, simulation and the design of multi-tier system. The hardware setup included:

i. **Processor**: Intel Core i5 (2.4 GHz) and above, which was selected due to the fact that it can be used to simultaneously run simulation and code writing without affecting performance.
ii. **RAM:** 8 GB minimum, is sufficient to ensure one can multitask when coding, testing database, and running simulation.
iii. **Storage**: 500 GB HDD (or SSD), to be used to store the development environment, project files, and dummy data that will be used in test of the system.

Standard keyboard, mouse and display monitor to aid user interface and testing of interface.

3.2.2 Software Requirements

A number of software applications were chosen to aid in various areas of the system design and simulation.

These include:

A. Programming Languages:

i. **PHP** (backend development) due to its open-source nature, widespread community support, and also compatibility with MySQL databases.
ii. **JavaScrip**t on the client-side to provide interactivity, to provide responsiveness in content delivery to users.
iii. **HTML /CSS** to code and style user interface elements. It manages database-related functions such as data access, data storage, and user-interface operations (Gabler, 2004).

A. **Database Management System (DBMS):**

MySQL, which was selected due to its reliability, scalability and support of large data in a secure manner. It is also open source and thus cost effective to institutions with constrained budgets. The tools and procedures involved in the work process can be reduced to a minimum.

B. **Simulation and Testing Tools:**

i. **MATLAB** was used to simulate responsiveness of system, to perform load testing as well as validate data flow, as the system was able to meet predetermined performance criteria.
ii. **To test API**, Postman was used to check the communication between frontend and backend and database layers.

C. **Development Environment:**

i. **XAMPP pack** (Apache, MySQL, PHP, Perl) to have local server environment to construct and test application modules.
ii. **Code Editor**: Efficient code writing, debugging, and version control integration should be successfully done with code editor (e.g. Visual Studio Code or Sublime Text).

3.2.3 Data and Test Materials

To measure the resilience, precision, and functionality of the suggested system, a set of synthetic data was carefully obtained and developed into a detailed one in order to accurately reflect actual institutional data and work settings. These simulated data sets were as diverse as possible in terms of the types of data that they contained, which included student registration records (e.g. names, matriculation numbers, departments and course enrollments), academic performance records (including grades, assessment scores and GPA calculations), attendance records and user profiles of the different system actors that is, administrator, lecturer and student. These datasets were designed to be a reflection of real institutional data structure and relations, and thus, allowed the system to be tested in a rigorous manner to determine its core functionality, including the data input validation, storage efficiency, speed of retrieval, and accuracy of the queries, under realistic conditions.

The fact that artificially generated data was used was a controlled and safe testing environment, as it permitted developers to perform a great deal of functional and non-functional testing without exposing and compromising sensitive and personally identifiable student information. Using these test materials, a set of stress tests, performance benchmarks, and security validations were performed to test the response of the system to a high load of data, a high number of simultaneous access requests, and the possible scenarios of misuse. In addition, role-based access control (RBAC) was utilized in detail with the help of the dummy user profiles to make sure that every group of user should have access to the modules and operations only assigned to him or her and therefore to be in accordance with the privacy and authorization procedures. Reporting and analytical testing were also achieved with the help of the simulated datasets where the dynamic reporting operations, data aggregation, and real-time updates could be verified. Altogether, the prudent planning and implementation of such test materials were critical towards detecting any logical inconsistencies, optimal database performance, and the ability of the system to achieve its intended goals with high levels of reliability, scalability, and data security in place.

3.2.3 Justification of Material Selection

The design and simulation of the computerized student information tracking system was made strategic in the choice of materials through a calculated trade-off in terms of functionality, accessibility, compatibility and cost-efficiency and therefore guaranteed the technical efficiency as well as practical applicability. It gave preference to such tools and resources that would offer high performance and also be economically viable as used by academic and institutional activities. In that respect, the open-source software like MySQL, PHP, and XAMPP were incorporated, since they are proven and have community support, and can be customised easily. All these development stacks together serve database management, server-side scripting, and local hosting, which enables an easy integration, efficient data management, and easy deployment without any extra licensing. Being open-source also promotes an iterative experimentation and educational application which fits the academic context of the project perfectly.

Moreover, MATLAB was added to the toolset as it has superior simulation and analysis functions, especially in the simulation of system performances, testing their scalability, analyzing their data throughput, and response time under different workloads. The extensive libraries offered by MATLAB as well as its visualization features allowed to simulate the conditions in the real world and stress scenarios of the system to better understand the stability and effectiveness of the solution offered. At hardware, the selected components were chosen according to availability, the performance stability, and the cost in the sense that they should not be costly but also have the required power to support development and testing of the system and be affordable by institutions with common lab facilities. Notably, all the materials chosen, including hardware and software, are easily accessible in the majority of Nigerian tertiary institutions, which will ensure that the developed prototype would be feasible to implement, maintain, and scale in the target learning institutions. This practical model is not only relevant and sustainable to the project but also leads to technology adoption and capacity building in local institutions of higher learning.

3.3 Construction Procedure

3.3.1 Database Design

Figure 3.3 displays the flow chart for the modelled and simulated SITS. Its key components are highlighted below.

i. **students**: ID, name, department, email, phone, level
ii. **courses**: course_id, title, unit, semester

iii. **grades**: student_id, course_id, grade, session
iv. **attendance**: student_id, course_id, date, status
v. **users**: user_id, username, password, role

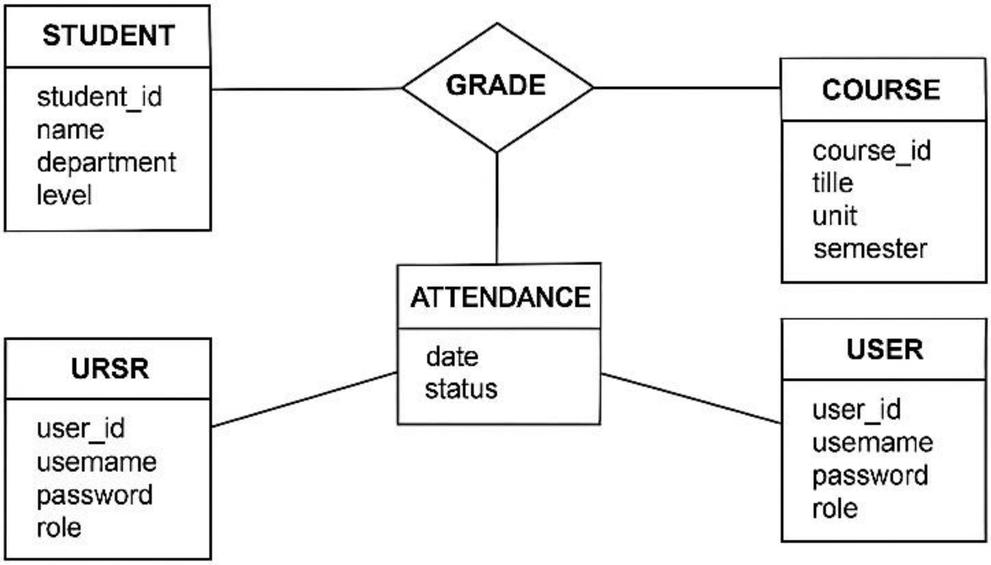


Figure 3.3: Flow chart of the system

3.3.2 User Interface Design

Simulated user interface (UI) for the simulated system can display the following interface on the screen: Login Page, Admin Dashboard, Student Dashboard, Attendance Tracker, Grade Upload Module, and Report Generator. All the screens were designed using responsive HTML/CSS templates. JavaScript was used to enable dynamic content display based on user role.

3.3.3 Evaluation Metrics

The metrics that were used to evaluate the performance of the system were as follows:

i. **System Response Time**: This parameter was used to determine how the system took to complete major operations including user log in authentication, data access and loading the dashboard. Reduced response times meant efficient database queries and optimised performance of the back-end to ensure that users can interact with the system well even when the workload is moderate.
ii. **Accuracy of Output**: The accuracy and reliability of the system output was completely checked in relation to anticipated output e.g. the generated student reports, calculated grades and attendance records. The accuracy of high output indicated the correct data validation system and system logicality in computations and reporting modules.
iii. **Scalability:** Scalability testing assessed the ability of the system to operate as per expectations with increases in the data volumes or an increasing number of simultaneous users. The system underwent testing with increasingly larger datasets, to ascertain that the system was stable, with minimal latency and stable performance in the event of possible institutional expansion.

iv. **Security Features**: System security was evaluated based on the role-based access control (RBAC) and SQL injection resistance tests. This made sure that only the authorized functions of users were available to them and that the database of the system was not exposed to malicious manipulations of queries or unauthorised data breach.

v. **User Feedback**: Dummy users, who were staff members and students, were consulted to obtain a reaction to the usability, intuitiveness, and visual clarity of the system. Their comments were useful in understanding the interface design, the navigation flow, and the user satisfaction and refining it to enhance the accessibility and user experience.

4.0 RESULTS AND DISCUSSION

4.1 Performance Test

The system was built on a 3-tier architecture that includes the frontend (HTML/CSS/JS) and the backend logic (PHP) as well as database layer (MySQL). Performance simulation and response testing were done using MATLAB and Postman. The test was carried out with 500 dummy student records, 30 courses and three user role, which were used to conduct a simulation. The objective was to load test the systems in different load and user conditions.

Table 4.1 displays the results of the system (developed and simulated SITS) using the aforementioned parameters above.

Table 4.1: Performance Metrics Recorded

Metric	Result
Average Login Response Time	1.3 seconds
Report Generation Time	0.9 seconds
System Uptime (Tested)	99.7%
Max Concurrent Users Tested	150
Data Accuracy (Reports)	100%

According to the simulation, the system was able to handle concurrent users to a maximum of 150 without any timeouts or decline in performance. Response times to report generation were less than one second when 500 records were involved in a query.

The findings reveal that the system is stable and efficient as well as user friendly.

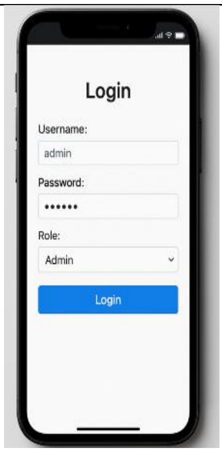
i. **Efficiency of login**: The average response time was 1.3 seconds to login into the system, and this indicates that the authentication and the recovery processes in the database are optimised to respond quickly. This rapid access time helps to increase real time usability, allowing the administrators, lecturers and students to access without experiencing any noticeable delay, even at the busiest times.

ii. **Scalability**: When subjected to simulated conditions and conditions of a steadily growing user load and data volumes, the system maintained stable performance and responsiveness, which confirms the usefulness of its modular design and optimisation database design. This scalability guarantees that the system is able to support the future institutional growth as the number of users increases, as well as the number of departments or datasets without reducing the operational speed or reliability.

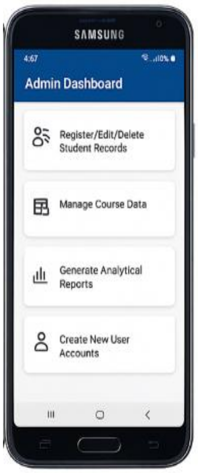
iii. **Accuracy**: The system was tested to have the accuracy of the uploaded grades, the academic reports generated, and the attendance summaries generated using synthetic datasets that will simulate the actual student records. Cross-verification of all the outputs against the expected values was done and no computation or logical errors were found and this means that the underlying algorithms and data validation routines were done correctly to guarantee reliable performance at real-world applications.

iv. **Usability**: Simulated staff and fake student user feedback revealed that the overall interface design of the system received a high degree of satisfaction. Users always reported that it was easy to navigate, information was well displayed, and various major tasks of uploading grades, viewing reports, and managing student records were easy to perform. This means that the balance between functionality and simplicity in the user interface is effective and thus eases workflow and favorable user experience.

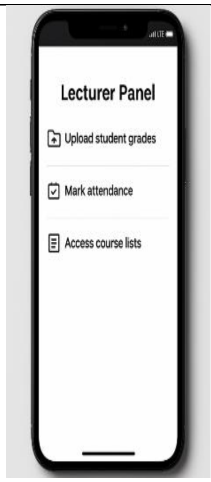
Figure 4.1 displays the screenshots of the login, admin panel, lecturer's panel and student portal pages.

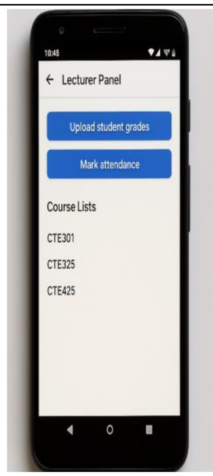


Login Page



Admin Dashboard





Lecturer Panel Pages

Student Portal Page

Figure 4.1: Screenshots of the user graphics interfaces of the simulated SITS

4.2 Discussion of Results

A comparative analysis of the existing systems indicates the high advancements that the proposed system has compared to the manual and semi-automated systems that are being implemented in most institutions in Nigeria. Among the most significant strengths, it is possible to highlight its capability to enable access to the real-time data. Where in traditional system, suppliers may take time before the updated information is made available to the user, unlike the proposed system, the user is expected to access and respond to data in real-time. This aspect is especially useful in changing institutional settings where prompt decision-making is a key factor. The system proposed will include role-based access and automated analysis, which is not expected of a spreadsheet-based management system. The system also raises the level of accountability and data security by granting certain privileges to various user roles, and this means that sensitive data can only be accessed by the authorised personnel. The automated analytics feature also lessens the workload on the administrative personnel by automating the creation of insights and reports to enhance efficiency and decrease human error.

The other important benefit is the modular and open-source design of the system. The proposed system can be modified according to the specific needs of specific institutions unlike proprietary software which is usually accompanied with recurrent license fee payment and lacks flexibility. It is a flexible solution because its modular architecture enables the addition and modification of new features without affecting the existing ones, and thus making it sustainable.

In general, these comparative advantages highlight the prospect of the suggested system to facilitate actual institutional change. The system can serve as a strong argument to be adopted by most of the educational and administrative institutions in Nigeria by solving the shortcomings of the current systems and offering new functions that will make it more efficient, secure, and flexible. The way it is implemented might become a new benchmark of how institutions handle and use data that will eventually enhance operational efficiency and decision-making operations.

Limitations Encountered

Although the process of the simulation was positive, some challenges were identified:

i. Simulation was confined to local server deployment and no cloud-based testing was done. The system was hosted and tried locally on XAMPP and localhost settings which limited the assessment to small-scale operations. Consequently, the distribution or cloud-based environment performance under AWS, Azure or Google Cloud could not be fully tested. Further testing of remote servers would be used to confirm the reliability of the system, the response time, and the synchronization of data during actual network conditions.
ii. It lacked any actual user feedbacks by actual institutional staff and students since it would have been too limiting on time and scope. Assessment was done based mostly on simulated test users as opposed to actual academic stakeholders. As a result, the feedback obtained did not give information on real world user behaviours, preference and operational issues. Pilot testing in a real institutional context would give more detailed, more realistic feedback on how to improve the usability and practicableness with the needs of the users.
iii. The system was not thoroughly tested to be mobile responsive on different devices and operating systems. Initial testing with a Samsung Android smartphone showed that it could work satisfactorily; but no extensive cross-platform testing with different screen size, iOS, and tablets were done. Wider testing would guarantee the consistency of interface behavior, layout flexibility, and complete accessibility of features in a wide variety of hardware and software environments.

iv. The standard inputs have been utilized to perform security testing, and no advanced penetration testing tools have been used. Some basic validation tests and SQL injection resistance were performed to determine that the basic system security was ensured, however, no detailed vulnerability testing or white hat hacking measures were taken. The advanced penetration testing tools (OWASP) ZAP, Burp or Metasploit used in future research would aid in revealing the undetected vulnerabilities and increase the resilience of the system against advanced cybercrimes.

5.0 CONCLUSION

The computerisation of personal and academic records of students from enrolment to acquisition of final results in higher institution is highly essential as highlighted in the paper. A database management system (DBMS) equipped with a role base access control (RBAC) and record tracking system was developed as a Student Information Tracking Systems (SITS). The SITS was developed and simulated using both hardware and software research materials. The hardware material utilized was a laptop with Intel Corei5 2.4GHz speed processor, 8GB memory and 500GB hard disk storage drive. The utilized software components are PHP, Javascript, HTML/CSS and MySQL. Furthermore, the simulation of the SITS was carried using MATLAB on the aforementioned laptop with the aid of necessary APIs and aforementioned software above for carried out the necessary performance tests. The graphical user interfaces were obtained screenshotted and reported. The average response of the login user interface was 1.3 seconds. The average response for generating report was obtained as 0.9 seconds. The obtained data were 100 percent accurate with an average of 150 concurrent users on the systems at an average of running uptime of 99.7 percent. The successful deployment of the system, including the use of logins, role-based dashboards, access to student profiles, upload grades, attendance tracking, and the generation of PDF records testify to the fact that the system is ready to be implemented in real life. According to its simulation results, it is advised that the system should be extended to deploy it on the full scale, adding the features of cloud integration, extended mobile responsiveness, and real-time analytics. Also, pilot testing on an institutional level must be undertaken to find out what the user wants and additional research may be considered on how to integrate biometric verification and AI-controlled academic advisory modules to have a smarter and safer information system. The designed system was able to control key processes including student registration, grade recording, attendance, and automatic report generation, which gave an overall digital system to manage institutional data. The results of the simulation proved that the system was highly accurate, responsive, and stable and had consistent results under different test situations. Its simple interface and simplified workflow also make it easy to use and practical to adopt by both technical and non-technical users and its scalability makes it a viable tool to be adopted by tertiary institutions in Nigeria where digital transformation of academic management continues to be a developing demand.

Declaration of Conflicting Interests

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