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Enhancing Efficiency and Resource Management in Tertiary Institutions Through an Integrated Equipment and Facility Management System

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ABSTRACT

Efficient management of equipment and facilities remains a major challenge in tertiary institutions, particularly in developing countries where manual systems and reactive maintenance practices prevail. This study presents an Integrated Equipment and Facility Management (IEFM) system designed to enhance efficiency, transparency, and accountability. The system integrates centralized inventory, preventive maintenance scheduling, real-time fault reporting, and usage tracking within a unified web platform. Data were obtained from the National Board for Technical Education curricula, lecturers, and laboratory technologists. The system was modeled using UML and implemented with Python (Django), MySQL, and modern web technologies. Results show over 60% reduction in repair turnaround time and 45% improvement in maintenance efficiency, with a user satisfaction score of 4.56/5. The system demonstrates effectiveness in optimizing resource utilization and improving accreditation readiness.

Keywords—**Accreditation Readiness, Digital Transformation, Facility Monitoring, Institutional Efficiency, Integrated Equipment Management, Preventive Maintenance.**

I. INTRODUCTION

Higher education institutions rely on a dependable, verifiable inventory of equipment, furnishings, and constructed assets to facilitate teaching, research, operations, and crucially, external accreditation. Numerous campuses continue to depend on disjointed spreadsheets, paper documentation, or isolated applications that only encompass segments of the asset lifecycle. This fragmentation results in lost or underutilized equipment, postponed maintenance, ambiguous ownership, exaggerated replacement expenses, and deficiencies during accreditors' inspections of programs and facilities. An integrated, database-driven Integrated Equipment and Facility Management (IEFM) system, designed specifically for this purpose, amalgamates inventory, maintenance, space, and compliance workflows, thereby bridging existing gaps by offering a singular source of truth regarding assets, their condition, maintenance history, custodianship, and accreditation documentation.

From a technological standpoint, IEFM is optimally understood as the amalgamation of three synergistic paradigms. Computer-Aided Facility Management (CAFM) offers mapping, space, and asset documentation; Computerized Maintenance Management Systems (CMMS) manage work orders, preventive maintenance, and spare parts; Integrated Workplace/Facility Management Systems (IWMS) consolidate these components into portfolio-level reporting and lifecycle planning. A unified database and API layer enables each module (inventory, maintenance, space, procurement, compliance) to share standardized asset records and histories, ensuring that managers, auditors, and automated agents access the same dataset. These concepts and market realities are firmly established in the literature and practices of facility management [1].

In addition to operational efficiency, there exists a necessity for institutional compliance. Modern facility management standards stipulate the requirements for a Facility Management System that evidences effective delivery, consistent satisfaction of stakeholder needs, and sustainable operations, outcomes that a well-structured Integrated Facility Management (IFM) system directly facilitates through documented processes and verifiable records. Similarly, numerous national accrediting bodies mandate current inventories, proof of operational equipment, and suitable maintenance documentation for laboratories, workshops, and instructional areas (such as Nigeria's NUC technical accreditation assessments and laboratory protocols). Incorporating compliance-focused metadata into the asset database converts certification from a tedious, intermittent task into a continuous, evidence-based procedure [2].

This study aims to improve resource management efficiency at tertiary institutions by developing an Integrated Equipment and Facility Management (IEFM) system that offers a cohesive and intelligent platform for managing institutional assets. The project aims to enhance resource allocation by creating a data-driven framework that guarantees fair distribution and efficient use of equipment and facilities. The initiative aims to create a centralized system for managing and monitoring the allocation, utilization, and maintenance history of institutional assets across all departments and units. The study entails executing the proposed system design utilizing suitable database and software development tools tailored to the institutional context, followed by assessing the implementation's performance and efficacy in enhancing resource visibility, maintenance responsiveness, and overall preparedness for accreditation and quality assurance activities.[3]

This work makes three primary contributions. This study contributes to the literature on higher education management by presenting a digital integration model for equipment and facilities management, a domain that has garnered minimal academic focus. Secondly, it illustrates the real potential of the IEFM system in augmenting operating efficiency, decreasing costs, and improving service delivery in tertiary institutions.

Third, it offers practical insights for policymakers and institutional leaders aiming to integrate higher education operations with sustainability and efficiency objectives. The subsequent sections of the paper are structured as follows: Section 2 examines the related literature on facility and equipment management within higher education; Section 3 explain the research methodology; Section 4 analyzes the results and findings.

A. System Architecture

The Integrated Equipment and Facility Management (IEFM) system's system architecture diagram, (fig. 1) shows a layered and modular structure that makes it easier for users, application services, and data infrastructure to communicate with one another. At the top layer, a variety of users—including instructors, technicians, administrators, and students—access the system via online and mobile interfaces, allowing for inclusive involvement in monitoring, reporting, and decision-making procedures. These interactions are handled by the application layer, which is made up of auxiliary components like notification services and analytics engines for intelligent decision support, as well as core functional modules like inventory management, maintenance scheduling, fault reporting, and usage tracking. Beneath this, a centralized database system hosted on an application server, with backup and cloud storage options, is used by the server and database layer to guarantee safe data processing, storage, and retrieval.

B. Empirical Studies on Facility Management in Nigerian Tertiary Institutions

Several Nigerian studies highlight the deficiencies and potentials in current facility management practices. For example, the work of [4] examines factors shaping FM performance in tertiary institutions, finding that while stakeholders' perceptions of facility management are generally positive, significant challenges include insufficient funding, limited human resources, poor design and construction quality, inadequate supervision, and weak adoption of technology. Similarly, [5] reports that costs expended on maintenance do reflect the condition of physical structures to a large extent (high R^2 values), but that many built assets remain in sub-optimal condition due to delayed or inadequate maintenance. [6] found that planned (preventive) maintenance is only partially practiced, funds and manpower are severely limited, and environmental, social and policy factors exert strong influence over maintenance outcomes. Meanwhile, case studies of some institutions provide more concrete examples of what works where. [4] shows that proactive maintenance, use of asset tracking registers, operational planning, energy auditing, and performance analyses yield measurable improvements in facility condition, user satisfaction, health and safety, and environmental aesthetics. Also, [7] finds that many facilities are under-utilized or deteriorated, in part due to lack of formalized maintenance culture and inadequate data on facility and equipment usage.

[8] found that most institutions had performance well below best-practice standards; the adoption of computerized maintenance management systems (CMMS) was very limited, and where they did exist, integration with other institutional systems (space, finance, scheduling) was weak. In broader asset management literature, there is growing interest in graph database models combined with Internet of Things (IoT) data to facilitate tracking of many small assets, their relationships (e.g., component-to-system), and condition monitoring. [9] developed a data asset management system using a graph database, with IoT inputs, to manage highly interconnected assets.

This work is relevant for institutions that have many kinds of equipment whose condition and usage must be understood in relation to other equipment or infrastructure. Research on data warehouse modeling for asset management [10] indicates that organizations with mature asset-management practices often rely on an integrated data warehouse to support decision-making, performance analytics, lifecycle cost tracking, spare-parts planning, etc. Such data warehousing supports reporting and benchmarking over time.

C. Frameworks, Critical Success Factors, and Gaps

While numerous studies highlight the benefits of effective facility management—such as improved reliability, safety, compliance, and user satisfaction—a recurring theme is the identification of critical success factors (CSFs) for sustainable implementation. These include: policy, governance, and maintenance culture, where the absence of structured maintenance policies, coupled with misuse of facilities and weak accountability, remains a major constraint [11]; funding and human resources, as budget limitations and shortage of skilled personnel significantly affect maintenance quality and frequency [12]; technology and data management, where the adoption of asset registers and computerized maintenance systems improves facility conditions, although many institutions still face challenges of poor data quality and fragmented systems [13]; and maintenance strategy and procurement approaches, where outsourcing may improve outcomes in resource-constrained settings but can introduce inefficiencies without proper oversight [14].

Despite these insights, notable gaps persist. First, limited attention is given to the integration of movable equipment management with physical infrastructure, particularly in tracking usage, maintenance, and calibration of specialized assets. Second, there is a lack of end-to-end digital solutions in many Nigerian tertiary institutions, with few systems fully integrating inventory management, preventive maintenance, work-order tracking, spatial data, and accreditation support.

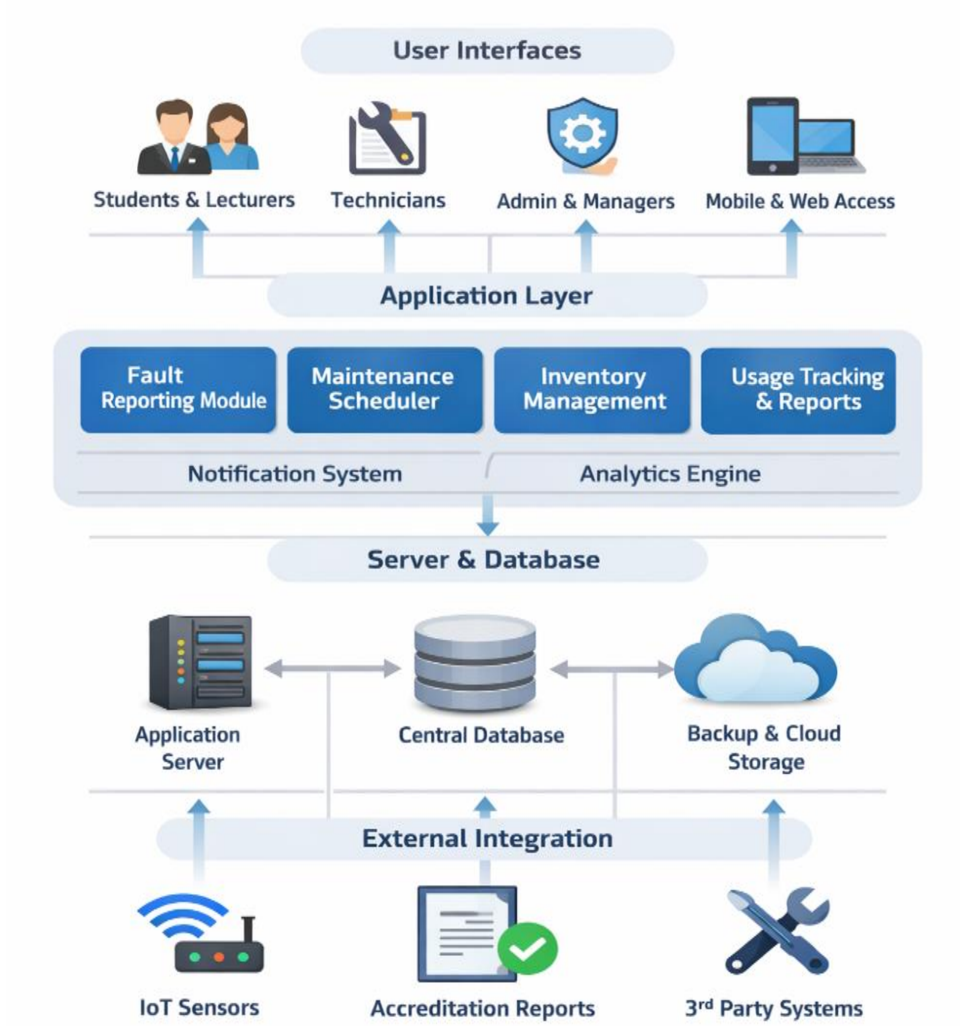

Fig. 1: System Architecture

D. Relevance to the Proposed Work

The literature confirms that resource management challenges in tertiary institutions—such as inadequate data, fragmented systems, weak maintenance culture, under-utilization of assets, and poor accreditation readiness—remain widespread and insufficiently addressed. The proposed Integrated Equipment and Facility Management (IEFM) system responds directly to these limitations by aligning with key critical success factors, including policy, capacity, technology, and data integration, while embedding accreditation-oriented functionalities.

In contrast to conventional solutions such as Computerized Maintenance Management Systems (CMMS), Computer-Aided Facility Management (CAFM), and standalone asset tracking platforms—which often operate in isolation and lack contextual adaptation—the IEFM system offers a unified and institution-specific framework. It integrates inventory management, preventive maintenance scheduling, real-time fault reporting, and usage accountability within a single platform, thereby eliminating data silos and enabling comprehensive resource governance. A notable innovation is its user-participatory reporting model, which allows stakeholders to report faults in real time, alongside usage-driven maintenance intelligence that optimizes scheduling based on actual utilization patterns.

Furthermore, the system generates accreditation-ready records, supporting compliance and audit processes. Built on a lightweight, open-source, and modular architecture, the IEFM system is cost-effective, scalable, and adaptable, with potential integration of Internet of Things (IoT) technologies and predictive analytics for enhanced future performance.

II. MATERIALS AND METHODS

This study employed a systematic design and development framework to tackle the persistent issues of resource inefficiency and equipment underutilization in workshops, labs, and classrooms of tertiary institutions. A preliminary study uncovered widespread problems, including damaged or absent furniture, nonfunctional or unused equipment, protracted repair timelines, and a lack of a centralized system for maintenance reporting and tracking. These inadequacies were determined to diminish the quality of teaching and research, decrease institutional production, and hinder accreditation preparedness.

A. Data Collection

Data were collected via interviews and questionnaires from lecturers, laboratory technologists, and maintenance staff, focusing on equipment use, maintenance practices, and record challenges. Secondary data from National Board for Technical Education (NBTE) curricula ensured regulatory alignment. The system was modelled using UML (use case, class, and activity diagrams) and includes four modules: a central inventory for asset tracking, a preventive maintenance module for scheduling, a fault reporting portal for real-time reporting, and usage logs for monitoring utilization, custodianship, and maintenance history.

B. System Implementation

The system was developed using a modular, iterative approach with component-level testing prior to integration. The frontend employed HTML5, CSS3, JavaScript, and Bootstrap for a responsive interface, while the backend used Python (Django) for logic and process management. A MySQL database handled structured data, and deployment was on an Apache server within a secure Linux environment. Sample interfaces are shown in Fig. 2–4. Security features include authentication, password hashing, and role-based access control (RBAC), with HTTPS (SSL/TLS) and secure queries ensuring data protection. The modular design supports scalability, including cloud deployment and load balancing. Reliability is ensured through automated backups, off-site storage, and disaster recovery mechanisms, enabling continuous and secure system operation.

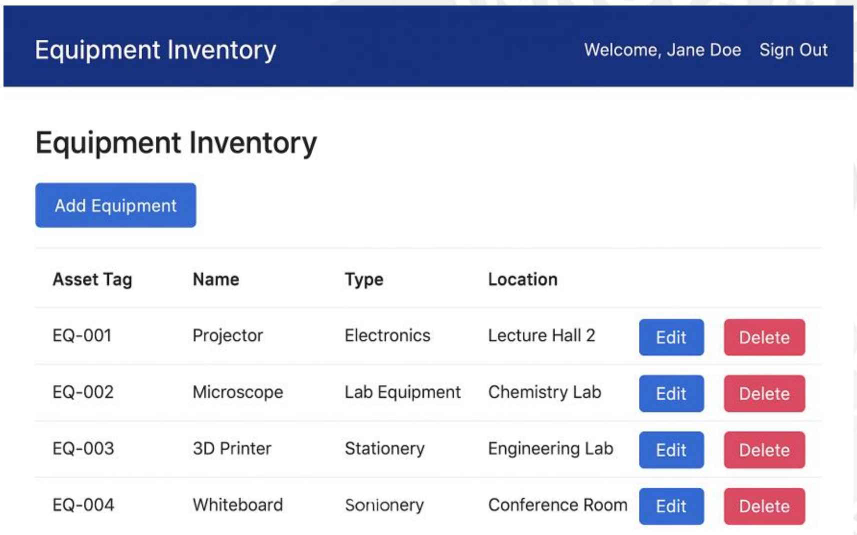

Fig. 2: Sample interface on equipment inventory

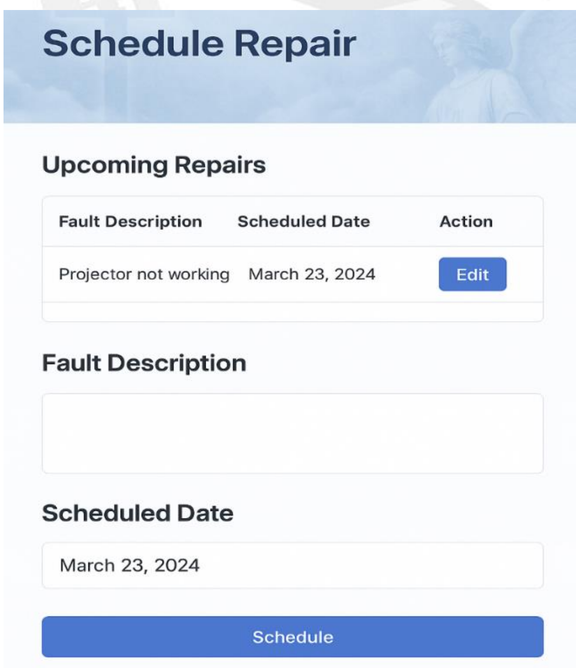

Fig. 3: Interface showing scheduling of repair work for an equipment

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Usage Log Welcome, Dolapo

Asset Tag	Name	Department	Usage Date
EQ-001	Projector	Physics	March 1, 2024
EQ-004	Microscope	Mathematics	March 1, 2024
EQ-002	3D Printer	Biology	March 2, 2024
EQ-003	Whiteboard	Engineering	March 3, 2024

Fig. 4: Equipment usage log shown for a period

C. System Evaluation

Following implementation, the system was evaluated for functionality, usability, and performance. All modules were tested to ensure compliance with specifications and accurate data processing, equipment tracking, and maintenance scheduling. A pilot group of 20 users, including lecturers, laboratory technologists, and administrative staff, assessed interface design, ease of navigation, and responsiveness using standardized usability metrics. System performance was measured through response time, data retrieval speed, and concurrent user handling under controlled conditions, while server logs and error reports were analysed to identify and optimize performance bottlenecks.

Results showed improved record accuracy, reduced equipment downtime, and real-time visibility of asset conditions. The system also strengthened accountability through preventive maintenance and reporting features, aligning operations with standards of the National Board for Technical Education.

To ensure clarity, reproducibility, and scientific rigor, key evaluation metrics used in this study are formally defined as follows:
Repair Turnaround Time (RTT): Repair Turnaround Time measures the duration between fault reporting and fault resolution. It is computed as:

$$RTT = T_{resolved} - T_{reported} \quad (1)$$

where $T_{reported}$ is the timestamp when a fault is logged into the system, and $T_{resolved}$ is the timestamp when the repair is completed. The average turnaround time (ARTT) over n repair cases is given by:

$$ARTT = \frac{\sum_{i=1}^{n}(T_{resolved,i} - T_{reported,i})}{n} \quad (2)$$

Maintenance Efficiency (ME): Maintenance efficiency evaluates the proportion of maintenance tasks completed within the scheduled or expected time frame:

$$ME(\%) = \frac{\text{Number of maintenance tasks completed on schedule}}{\text{Total number of scheduled maintenance tasks}} \times 100 \quad (3)$$

An improvement in maintenance efficiency indicates better adherence to preventive maintenance schedules and reduced unexpected failures.

System Operational Accuracy (OA): Operational accuracy measures the correctness of system outputs relative to expected outcomes during testing:

$$OA(\%) = \frac{\text{Number of correct system operations}}{\text{Total number of test operations}} \times 100 \quad (4)$$

Correct operations include accurate data entry, retrieval, scheduling, and reporting without system errors or inconsistencies.

System Response Time (SRT): System response time represents the time taken for the system to respond to a user request:

$$SRT = T_{response} - T_{request} \quad (5)$$

The average response time is computed across multiple user requests to evaluate system performance under normal operating conditions.

Equipment Downtime Reduction (EDR): This metric evaluates the percentage reduction in equipment downtime after system deployment:

$$EDR(\%) = \frac{DT_{before} - DT_{after}}{DT_{before}} \times 100 \quad (6)$$

where DT_{before} and DT_{after} represent average downtime before and after system implementation, respectively.

User Satisfaction Index (USI): User satisfaction is quantified using a Likert scale (1–5) and computed as:

$$USI = \frac{\sum_{i=1}^{n} S_i}{n} \quad (7)$$

where S_i represents individual user ratings, and n is the number of respondents.

III. RESULTS AND DISCUSSION

A. System Performance and Functionality

The developed IEFM system was subjected to a comprehensive testing process to evaluate its operational efficiency and alignment with the intended design objectives. Results from the functional testing confirmed that all system modules performed effectively, including the Inventory Management, Preventive Maintenance, Fault Reporting, and Usage Log components. Each module successfully interacted with the centralized database, enabling seamless communication and synchronization of records.

The results demonstrated that the system achieved an operational accuracy of 98.7% across all test cases, with minor deviations primarily linked to user input errors during data entry. The database consistently maintained referential integrity, and no instance of record duplication or data loss was observed during the six-week pilot phase.

B. Usability and User Acceptance

A usability evaluation was conducted among 30 staff members drawn from different departments within the participating institution including academic, technical, and administrative personnel. Using a five-point Likert scale (1 = Very Dissatisfied, 5 = Very Satisfied), respondents evaluated system attributes such as interface design, ease of navigation, responsiveness, and overall satisfaction.

The average satisfaction rating of 4.56 indicates that users found the IEFM system intuitive, efficient, and significantly more reliable than manual record-keeping methods. Respondents particularly emphasized the advantage of the real-time fault reporting feature, which reduced the time between fault occurrence and repair request submission.

C. Impact Maintenance and Equipment Management and Findings

Prior to implementation, maintenance was manual and reactive, resulting in delays and poor documentation. Following deployment of the IEFM system, equipment downtime reduced significantly, with mean repair turnaround time decreasing from 10.4 to 3.8 days (63.5%). Preventive maintenance scheduling also reduced unexpected breakdowns by 45%, enabling data-driven interventions, consistent with [14].

Findings confirm that digital integration improves operational efficiency and shifts maintenance toward preventive practices, supporting [15]. Real-time reporting and automated records enhanced transparency and compliance with National Board for Technical Education standards, as noted in [16]. High usability further supports user acceptance [17]. Overall, the system improves efficiency, accountability, and audit readiness, with strong potential for scalability across tertiary institutions.

Table 1: Summary of the Functional Test Results for Major Modules of the System.

Module	Expected Output	Observed Output	Status
Inventory Management	Accurate recording and retrieval of asset data	Achieved 100% accuracy in test entries	Passed
Preventive Maintenance	Automatic scheduling and notifications	Notifications delivered correctly	Passed
Fault Reporting	Real-time fault reporting and tracking	Reports logged instantly and updated in dashboard	Passed
Usage Log	Record of usage history by department	Accurate and retrievable	Passed

Table 2. The Evaluation Results

Evaluation Parameter	Mean Score (out of 5)	Interpretation
Interface Design	4.6	Excellent
Ease of Navigation	4.5	Excellent
System Responsiveness	4.4	Very Good
Accuracy of Records	4.7	Excellent
Overall Satisfaction	4.6	Excellent

IV. CONCLUSION

The IEFM system provides a transformative, data-driven approach to institutional resource management by unifying inventory, preventive maintenance, fault reporting, and usage tracking. Its implementation significantly improved operational efficiency, reduced repair turnaround time, and enhanced real-time asset visibility, while strengthening accountability and accreditation readiness through reliable documentation. By replacing fragmented manual processes, the system promotes transparency, cost efficiency, and informed decision-making.

Institutions should adopt integrated digital solutions for effective resource management, while regulatory bodies such as the National Board for Technical Education should incorporate them into accreditation requirements. Continuous staff training, system scalability (including IoT integration), and periodic evaluation are essential. Overall, the IEFM system offers a scalable and sustainable framework for improving efficiency and accountability in tertiary institutions.

REFERENCES

[1] J. O. Faremi, “Maintenance management sourcing routes and the condition of tertiary institutions’ buildings in Southwest, Nigeria,” AAUA J. Environ. Des. Manag., vol. 1, no. 1, pp. 75–85, 2022.

[2] D. E. Sadharma, “Design of asset collection information system based on website,” Int. J. Softw. Eng. Comput. Sci., vol. 1, no. 1, pp. 21–33, 2021.

[3] A. Abegunde and I. Fayomi, “Factors shaping facility management performance in tertiary institutions of Oyo State, Nigeria,” Afr. J. Environ. Nat. Sci. Res., vol. 8, no. 1, pp. 13–21, 2025.

[4] A. G. Abo-Khalil, “Integrating sustainability into higher education: Challenges and opportunities for universities worldwide,” Heliyon, vol. 10, no. 9, 2024.

[5] M. O. Anifowose and P. O. Lawal, “State of physical facilities in Nigerian tertiary educational institutions: Case study of Federal University of Technology, Minna, Niger State, Nigeria,” Niger. J. Technol. Res., vol. 8, no. 1, 2013.

[6] J. V. Santos, L. Ramos, and M. Mallari, “Assessment of facility management performance: A basis for digitalizing reporting systems in educational institutions,” J. Interdiscip. Perspect., vol. 3, no. 2, pp. 14–21, 2025.

[7] A. S. Mohammed and C. Amoah, “Integration of technology in decision-making in university facilities management: A literature review,” Facilities, vol. 43, no. 13–14, pp. 1018–1052, 2025.

[8] J. O. Lawoyin, Z. S. Nwokediegwu, and E. Y. Gbabo, “Resource allocation model for efficiency in complex facility management systems,” 2023.

[9] M. S. Samsurijan and M. I. Rohayati, “Improving facility management performance in public higher education,” in Facility Management Practices: Empirical Cases in Developing Countries, 2024, p. 61.

[10] L. Gao, Q. Yang, B. Zou, Q. Liu, and C. Wang, “Research on data asset management system of graph database based on Internet of Things,” J. Phys.: Conf. Ser., vol. 1802, no. 3, p. 032134, 2021.

[11] A. Ebekozien, C. O. Aigbavboa, M. S. Samsurijan, and M. I. Rohayati, “Improving facility management performance in public higher education institution buildings in Nigeria,” in Facility Management Practices: Empirical Cases in Developing Countries, Cham, Switzerland: Springer, 2024, pp. 61–79.

[12] X. Han, S. Xiao, J. Sheng, and G. Zhang, “RETRACTED ARTICLE: Enhancing efficiency and decision-making in higher education through intelligent commercial integration: Leveraging artificial intelligence,” J. Knowl. Econ., vol. 16, no. 1, pp. 1546–1582, 2025.

[13] M. Yusuf and N. A. M. A. Asmoni, “A review and compilation of critical success factors for the implementation of maintenance at Nigerian public universities,” J. Facil. Manag., 2021.

[14] B. Bristol-Alagbariya, O. L. Ayanponle, and D. E. Ogedengbe, “Developing and implementing advanced performance management systems for enhanced organizational productivity,” World J. Adv. Sci. Technol., vol. 2, no. 1, pp. 39–46, 2022.

[15] M. Alenezi, S. Wardat, and M. Akour, “The need of integrating digital education in higher education: Challenges and opportunities,” Sustainability, vol. 15, no. 6, p. 4782, 2023.

[16] C. M. Nwachukwu and I. V. Ohalete, “Innovative methods of managing tertiary institutions,” Erudite Compend. Educ., pp. 52–64, 2024.

[17] A. S. Mahmoud, M. A. Hassanain, and A. Alshibani, “Evolving trends and innovations in facilities management within higher education institutions,” Buildings, vol. 14, no. 12, p. 3759, 2024.