



Original Research Article

Strategic Maintenance Planning for Engineering Workshops and Estate Departments: A Case Study of the University of Benin

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ABSTRACT

This study explores the importance of strategic maintenance planning within the context of university engineering workshops and estate departments, using the University of Benin (UNIBEN) as a case study. These facilities, integral to academic and operational efficiency, face growing challenges from aging infrastructure, limited budgets, and insufficient planning, which impede learning, research, and sustainability. A mixed-methods approach was employed, using structured questionnaires for university personnel and external professionals, with responses weighted by role and experience. Analytical techniques included descriptive statistics, mode analysis, and Relative Importance Index (RII). Findings reveal a predominant reliance on reactive (RII = 0.80) and preventive maintenance (RII = 0.76) at UNIBEN, with limited adoption of predictive (RII = 0.60) and condition-based (RII = 0.56) strategies. This contrasts with external workshops, which showed higher application levels for advanced models and better maintenance training. The study identifies key barriers, including budgetary constraints and poor documentation, emphasizing the urgent need for digital tools like a Computerized Maintenance Management System (CMMS), continuous training, and data-driven frameworks to transition universities toward a proactive maintenance culture. Ultimately, the report provides strategic insights for enhancing infrastructure reliability, reducing operational costs, and improving educational outcomes in institutional environments.

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1. INTRODUCTION

Universities operate as complex ecosystems that balance teaching, research, and community service, heavily relying on physical infrastructure and technical facilities to function effectively (Omodan, 2024). This ecosystem's most significant yet regularly overlooked components are engineering

workshops and university estates. Engineering workshops serve as the practical backbone of engineering education, enabling students to apply theoretical knowledge through hands-on experimentation with machinery ranging from traditional lathes and milling machines to advanced CNC systems and 3D Printers (Eberhardt *et al.*, 2017).

University estates, in contrast, encompass the broader campus infrastructure, including lecture halls, laboratories, utilities, offices, dormitories, and communal spaces that sustain academic and social life. Together, these facilities form the foundation upon which educational quality, research productivity, and institutional sustainability are built, thereby, influencing the quality of life (QoL) of the end user, in this case, students (Gür, 2024). Maintaining these assets is not automatic and therefore requires purposeful, thought-out strategic planning. A well-planned maintenance strategy goes beyond simply responding to equipment failures; it involves proactive actions such as scheduled upkeep, predictive diagnostics, and long-term investment planning to ensure an asset runs efficiently and safely (Mobley, 2002). Despite their importance, the maintenance of university engineering workshops and estates has often been approached reactively, addressing equipment breakdowns and infrastructure failures only after they occur (West *et al.*, 2024). This approach not only disrupts academic continuity but also results in higher maintenance costs, unavailability of machinery, and safety risks (West *et al.*, 2024).

Taking the University of Benin (UNIBEN) as a case study, decades of reliance on reactive maintenance fixated with a weak maintenance culture have led to obvious outcomes, including the abandonment of workshop machinery as well as the central air-conditioning units placed in the Faculty of Engineering, amongst others, as commonly seen in Nigerian public tertiary institutions (Ogunode *et al.*, 2022). In that regard, issues ranging from unreliable workshop equipment to frequent utility breakdowns undermine the quality of student training and research while exposing staff and students to risks. These challenges are exaggerated by limited budgets, aging infrastructure, and the increasing technical demands of modern engineering education (Nwankwo *et al.*, 2024).

Recent studies across Nigerian universities and West Africa report persistent reliance on reactive and basic preventive maintenance, limited documentation, and funding constraints, with negative effects on service quality and learning outcomes (Ige and Asaju, 2024; Sa'ad *et al.*, 2025; Odeyemi *et al.*, 2019). Empirical work in North-East Nigeria shows that strategy selection is shaped by resource scarcity and utilities reliability, and that stronger facilities management processes improve performance (Sa'ad *et al.*, 2025). Case studies from Lagos and Ilorin identify skills gaps, weak maintenance culture, and delayed interventions as recurrent causes of deterioration (Odeyemi *et al.*, 2019; Olatunji *et al.*, 2016). There is emerging evidence that digital approaches such as Building Information Modelling (BIM) and Computerized Maintenance Management Systems (CMMS) can improve asset information and scheduling in Nigerian universities (Odeniran *et al.*, 2025). Regional research on predictive maintenance also points to measurable gains in reliability and energy efficiency in service sectors, supporting the integration of data-driven monitoring in campus operations (Adeleke *et al.*, 2025). However, this study emphasises the comparative difference in benchmarks between university and external workshops in Nigeria, revealing specific capability gaps in diagnostics, training, and documentation that a risk-based, CMMS-supported roadmap can address.

An emerging body of literature emphasises the importance of strategic maintenance planning in sustaining physical assets and ensuring operational efficiency. Maintenance approaches and techniques in Preventive Maintenance (PM), Predictive Maintenance (PdM), and Condition-Based Maintenance (CBM) have been developed to enhance reliability, reduce downtime, and optimize costs (Wu and Zuo, 2010; Van Dinter *et al.*, 2022; De Jonge *et al.*, 2017). More advanced frameworks such as Reliability-Centred Maintenance (RCM) and Risk-Based Maintenance (RBM) further integrate risk management and quality assurance principles, ensuring that resources are directed toward the most critical assets (da Silva *et al.*, 2023). While these models have been successfully applied in industrial contexts, their implementation in higher education institutions, particularly in resource-constrained environments remains limited.

This study addresses this gap by examining the strategic maintenance practices within UNIBEN's engineering workshops and estates. It investigates the current maintenance models in use, identifies barriers to effective planning, and compares internal practices with external engineering workshops to highlight opportunities for improvement. By integrating insights from both internal partakers and industry professionals, the study aims to propose practical, context-sensitive recommendations that can support universities in transitioning from reactive to proactive, technology enabled maintenance systems. Ultimately, this research contributes to strengthening the sustainability of university infrastructure, improving the quality of engineering education, and nurturing safer, more productive learning environments.

2. MATERIALS AND METHODS

2.1. Instrumentation

The research instrument used for this study was the questionnaire. The questionnaire was developed by the researcher. The instrument has three sections. The first section contained the respondent's personal data, which demanded information covering age, sex, job, role etc. The second and third sections were used to acquire information from university staffs and external professionals, respectively. Respondents were to indicate their degree of agreement with each item on a five-point Likert-type scale.

2.2. Validation of Instrument

The questionnaire was constructed in relation to the stated research topic. Corrections and valuable suggestions were proffered by the paper supervisor, Prof. G.O. Ariavie. After thorough scrutiny of each item, the questionnaire was found to be adequately reliable and suitable for the research, as it was capable of eliciting relevant information from the target respondents.

2.3. Procedure for Data Collection

To administer the questionnaire, the researcher engaged both the university staff of the engineering workshop and estates, as well as external professionals who frequently interact with and are familiar with engineering workshops and maintenance practices. Physical copies of the questionnaire were distributed to the university staff, completed, and collected on the same day. For the external professionals, however, a more detailed online form was designed to capture deeper insights into external practices and approaches to workshop management.

2.4. Weighting Scheme

Weights were applied to survey responses based on Role and Experience. The total respondent weight (W) was calculated using Equation 1:

$$Total\ Weight = Role\ Weight \times Experience\ Weight \quad (1)$$

Where:

Role: Student (1), Lecturer/Administrative Staff (2), Maintenance Engineer/Technical Personnel (3)

Experience: <1 Year (1), 1-5 Years (2), 6-10 Years (3), 11-15 Years (4), 16+ Years (5)

2.5. Analysis Techniques

Descriptive Statistics: Weighted mean and mode were computed for key indicators.

Relative Importance Index (RII): Used to rank maintenance factors, calculated using Equation 2.

$$RII = \frac{\sum(W \times X)}{A \times \sum N} \quad (2)$$

Where W = Respondent Weight, X = Likert Score (1 to 5), A = Maximum Likert Score (5), N = Total Weighted Sum of Respondents.

3. RESULTS AND DISCUSSION

3.1. Internal Workshop Maintenance Model Proficiency

To assess the current maintenance practices within the University of Benin, the Relative Importance Index (RII) was calculated based on personnel proficiency responses. The results are presented in Table 1. The findings in Table 1 indicate a strong reliance on a reactive maintenance (RII = 0.80) approach. This is followed by preventive maintenance (RII = 0.76), suggesting that scheduled upkeep is also a common practice. This aligns with findings from other Nigerian universities, which note a persistent reliance on reactive and basic preventive strategies (Ige and Asaju, 2024; Odeyemi *et al.*, 2019). The significantly lower scores for modern, proactive strategies like predictive (RII = 0.60) and condition-based maintenance (RII = 0.56) reveal a significant gap in the adoption of data-driven models. This gap contributes to the weak maintenance culture described by Chidi *et al.*, 2017, where equipment is often run to failure, leading to higher long-term costs and academic disruptions (Nwankwo *et al.*, 2024).

Table 1: RII values for proficiency of maintenance model in internal workshops

Classification	RII
Reactive maintenance model	0.80
Preventive maintenance model	0.76
Predictive maintenance model	0.60
Condition-based maintenance model	0.56

3.2. External Workshop Maintenance Practices

For benchmarking, a parallel survey was conducted with external engineering professionals. The results in Tables 2 and 3 provide a comparative look at maintenance practices in commercial or non-academic environments. Table 2 presents the unweighted descriptive statistics for external engineering workshops, serving as the raw empirical foundation for the RII analysis that follows in Table 3. The data reveals that external professionals perceive their operational competency as high, evidenced by the highest mean scores for the Application level of current maintenance model (3.76) and Level of understanding of maintenance models (3.69), with a mode of 4 suggesting most respondents rated these capabilities as high. This aligns with the work of Swanson (2001), who suggests that a strong conceptual understanding of maintenance strategies is a critical foundation to advanced technical performance, even if execution lags in other areas. Conversely, the table highlights specific operational gaps, particularly in Documentation quality of maintenance data, which received the lowest mean score of 3.19 and a lower mode of 4. Also, the Effectiveness of maintenance planning and scheduling which is linked to the documentation quality had a mean score of 3.33 and mode of 3. This deficiency mirrors the challenges identified by Muchiri *et al.* (2011), who noted that poor data acquisition and documentation quality frequently hinder effective maintenance performance measurement and decision-making. Furthermore, the Level of maintenance training provided (3.31) had a mode of 3, indicating a moderate rather than high frequency of training. This finding is consistent with Ahuja and Khamba (2008), who identify insufficient continuous training and education as a persistent, primary barrier to the successful implementation of maintenance management systems in industrial contexts.

Table 2: Descriptive statistics for external workshops (Unweighted)

Item	Mean	Std Dev	Min	Max	Mode
Level of understanding of maintenance models	3.69	0.92	1	5	4
Application level of current maintenance model	3.76	0.91	2	5	4
Level of maintenance training provided	3.31	1.20	1	5	3
Documentation quality of maintenance data	3.19	1.17	1	5	4
Effectiveness of maintenance planning and scheduling	3.33	1.00	1	5	3

From Table 3, the external workshop data shows a higher application level (RII = 0.783) and understanding (RII = 0.785) of their chosen maintenance models. This aligns with Eti *et al.* (2006), who observed that competitive business environments in Nigeria have increasingly compelled industries to

adopt more strategic, results-oriented maintenance functions. Notably, their maintenance planning is rated higher (RII = 0.705) than their documentation (RII = 0.674) or training (RII = 0.699). While documentation is a shared weakness, the external workshops demonstrate a more robust framework. Okosun and Olagunju (2017) support this, identifying that while documentation remains a challenge across the board, the lack of computerized maintenance management systems (CMMS) and data records is significantly more acute and detrimental in institutional settings.

Table 3: RII values for external workshops

Item	RII
Level of understanding of maintenance models	0.785
Application level of current maintenance model	0.783
Effectiveness of maintenance planning and scheduling	0.705
Level of maintenance training provided	0.699
Documentation quality of maintenance data	0.674

This difference underscores the need for universities to adopt more structured, knowledge-based strategies, moving beyond the fragmented, reactive culture. Asiabaka (2008) strongly supports this implication, arguing that the maintenance of educational facilities in Nigeria is frequently characterized by a breakdown maintenance (reactive) culture due to the absence of clear maintenance policies. Furthermore, James *et al.* (2014) emphasize that to escape this reactive cycle, institutions must transition to preventive practices prioritized through policy reforms and data-driven planning, rather than ad-hoc responses to failure.

3.3. Key Challenges and Barriers

The survey data, supported by qualitative feedback, highlighted several challenges. Budgetary constraints were notorious, limiting resource allocation. This directly impacts the ability to stock spare parts or invest in training, which was identified as inadequate (RII = 0.699 even in external shops). Poor documentation (RII = 0.674) further complicates planning and scheduling, creating a cycle of inefficiency. These findings are consistent with Olatunji *et al.* (2016), who identified skills gaps and delayed interventions as major causes of deterioration.

4. CONCLUSION

These results reiterate the external workshop trends but also highlight how UNIBEN's resource limitations, fragmented departmental roles, and inadequate training are even more pronounced in a university setting. Challenges such as a lack of advanced diagnostic tools, limited funding, staff unfamiliarity with modern models, incompatibility of old systems with new technologies and poor inter-departmental coordination create systemic barriers that prevent the university from evolving its maintenance strategy.

Both internal and external data strongly emphasize the need for an integrated, multi-model approach to maintenance. While preventive maintenance remains foundational, it is insufficient on its own to address the complex demands of modern workshop and estate management. To strengthen maintenance practices, UNIBEN and similar institutions should adopt a holistic strategy that integrates predictive maintenance, capitalising on sensor data for real-time fault detection, alongside condition-based maintenance, which uses diagnostics to monitor equipment health. Continuous, role-specific training should also be institutionalized to build capacity among students, technicians, and academic staff. Furthermore, maintenance efforts should prioritize critical assets through a risk-based framework that ensures resources are directed where they are most needed. Securing an adequate budget is equally essential, with proactive maintenance justified by its long-term cost-saving benefits in university planning. Finally, the adoption of a Computerized Maintenance Management System (CMMS) for scheduling, logging, and asset tracking will digitalize documentation and enhance overall efficiency (Labib, 2008).

These findings affirm that external industry practices offer valuable benchmarking standards. They can guide institutions like UNIBEN in transitioning from a fragmented, reactive culture to a sustainable, strategically coordinated maintenance ecosystem, improving infrastructure longevity and enhancing safety, training quality, and operational efficiency.

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6. CONFLICT OF INTEREST

There is no conflict of interest associated with this work.

REFERENCES

- Adeleke, F. B., Odetoye, A. S., Akerele, E. E., Folorunso, O. S., and Bashiru, A. A. (2025). Predictive Maintenance and Its Role in Energy Efficiency in The Hospitality Industry. *Malete Journal of Accounting and Finance*, 5(2), pp.439-447. <https://majaf.com.ng/index.php/majaf/article/view/249>
- Ahuja, I. P. S., and Khamba, J. S. (2008). Total productive maintenance: literature review and directions. *International Journal of Quality & Reliability Management*, 25(7), pp.709-756. <https://doi.org/10.1108/02656710810890890>
- Asiabaka, I. P. (2008). The Need for Effective Facility Management in Schools in Nigeria. *New York Science Journal*, 1(2), pp.10-21. <http://www.doi.org/10.7537/marsnys010208.02>
- Chidi, E. E., Shamsudeen, M., Oladipupo, F. T., and Owolabi, A. J. (2017). An Assessment of Maintenance Culture on Public Buildings in Nigeria (A Case Study of osun State). *IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)*, 14(5), pp.53-57. <https://www.iosrjournals.org/iosr-jmce/papers/vol14-issue5/Version-3/11405035357.pdf>
- da Silva, R. F., Melani, A. H. d. A., Michalski, M. A. d. C., and de Souza, G. F. M. (2023). Reliability and Risk Centered Maintenance: A Novel Method for Supporting Maintenance Management. *Applied Sciences*, 13(19), 10605. <https://doi.org/10.3390/app131910605>
- de Jonge, B., Teunter, R., and Tinga, T. (2017). The influence of practical factors on the benefits of condition-based maintenance over time-based maintenance. *Reliability Engineering and System Safety*, 158, pp.21-30. <https://doi.org/10.1016/J.RESS.2016.10.002>
- Eberhardt, A. W., Tillman, S., Kirkland, B., and Sherrod, B. (2017). A Project Course Sequence in Innovation and Commercialization of Medical Devices. *The American society of engineers: Journal of Biomechanical Engineering*; 139(7), 071003. <https://doi.org/10.1115/1.4036441>
- Eti, M. C., Ogaji, S. O. T., and Probert, S. D. (2006). Strategic maintenance-management in Nigerian industries. *Applied Energy*, 83(3), pp.211-227. <https://doi.org/10.1016/J.APENERGY.2005.02.004>
- Gür, M. (2024). Assessment of Student Quality of Life in Relation to University Campus. *Sustainability*, 16(20), 8906. <https://doi.org/10.3390/su16208906>
- Ige, V. O., and Asaju, A. O. (2024). Facility Maintenance Culture in Nigerian Universities: A Case Study of a Public University. *Facility Management Practices: Empirical Cases in Developing Countries*, pp.1-17. https://doi.org/10.1007/978-3-031-65321-6_1
- James, O. D., Lekan, A. M., Gani, J., Tunji-Olayeni, P., Joy, P., and Ignatious, O. (2014). Assessing The Effectiveness of Maintenance Practices in Public Schools. *European International Journal of Science and Technology*, 3(3), pp.103-109. <https://ejst.org.uk/files/images/frontimages/gallery/vol. 3 no. 3/12.pdf>
- Labib, A., Kobbacy, K. A. H., and Prabhakar Murthy, D. N. (2008). Computerised Maintenance Management Systems. *Springer Series in Reliability Engineering*, 8, pp.417-435. https://doi.org/10.1007/978-1-84800-011-7_17
- Mobley, R. K. (2002). Establishing a Predictive Maintenance Program. *An Introduction to Predictive Maintenance*, pp.325-351. <https://doi.org/10.1016/B978-075067531-4/50015-4>
- Muchiri, P., Pintelon, L., Gelders, L., and Martin, H. (2011). Development of maintenance function performance measurement framework and indicators. *International Journal of Production Economics*, 131(1), pp.295-302. <https://doi.org/10.1016/J.IJPE.2010.04.039>

- Nwankwo, A. M., Nwankwojike, B. N., and Uche, R. (2024). Causes and Effects of Poor Facilities Management In Nigerian Tertiary Institutions. *Journal of Engineering for Development*, 16(1), pp. 51-71.
<https://jedev.com.ng/volume-16-issue-1-no-5/>
- Odeniran, O., Daramola, S. A., Fadamiro, J. A., and Agboola, O. O. (2025). Adoption of BIM in maintenance of universities in Nigeria. *Iconic Research and Engineering Journals*, 8(11), pp.1601-1607.
<https://www.irejournals.com/paper-details/1708543>
- Odeyemi, S. O., Adeniyi, O. I., and Amoo, A. I. (2019). Assessment on building maintenance in Nigerian Universities: A case study of University of Ilorin. *Nigerian Journal of Technology*, 38(3), pp.566-572.
<https://doi.org/10.4314/NJT.V38I3.4>
- Ogunode, N. J., Jegede, D., Olamoyegun, S. O., Akinjobi, F. N., and Olatunde-Aiyedun, T. G. (2022). Effects of Project (Infrastructure Facilities) Abandonment in Public Tertiary Education in Nigeria and the Way Forward. *Electronic Research Journal of Behavioural Sciences*, 5(1), pp.20-32
https://www.researchgate.net/publication/363251124_Effects_of_Project_Infrastructure_Facilities_Abandonment_in_Public_Tertiary_Education_in_Nigeria_and_the_Way_Forward
- Okosun, B. O., and Olagunju, R. E. (2017). Assessment of Factors Contributing to Maintenance Problems in Higher Institutions in Niger State, Nigeria. *Journal of Building Performance*, 8(1), pp.2180-2106.
<https://spaj.ukm.my/jsb/index.php/jbp/article/view/213>
- Olatunji, S. O., Aghimien, D. O., Oke, A. E., and Akinkunmi, T. (2016). Assessment of Maintenance Management Culture of Tertiary Institutions in Nigeria. *Civil and Environmental Research*, 8(6), pp.98-105
<https://iiste.org/Journals/index.php/CER/article/view/30951>
- Omodan, B. I. (2024). Redefining university infrastructure for the 21st century: An interplay between physical assets and digital evolution. *Journal of Infrastructure, Policy and Development*, 8(4), 3468
<https://doi.org/10.24294/JIPD.V8I4.3468>
- Sa'ad, M., Udoekanem, N., Kemiki, O., and Adama, U. (2025). Effectiveness of facilities management strategies employed by universities in Northeast Nigeria. *Iconic Research and Engineering Journals*, 8(7), pp.459-472.
<https://www.irejournals.com/paper-details/1706976>
- Swanson, L. (2001). Linking maintenance strategies to performance. *International Journal of Production Economics*, 70(3), pp.237-244. [https://doi.org/10.1016/S0925-5273\(00\)00067-0](https://doi.org/10.1016/S0925-5273(00)00067-0)
- van Dinter, R., Tekinerdogan, B., and Catal, C. (2022). Predictive maintenance using digital twins: A systematic literature review. *Information and Software Technology*, 151, 107008. <https://doi.org/10.1016/J.INFSOF.2022.107008>
- West, J., Siddhpura, M., Evangelista, A., and Haddad, A. (2024). Improving Equipment Maintenance—Switching from Corrective to Preventative Maintenance Strategies. *Buildings*, 14(11), 3581.
<https://doi.org/10.3390/buildings14113581>
- Wu, S., and Zuo, M. J. (2010). Preventive Maintenance Models: A Review Linear and Nonlinear Preventive Maintenance Models. *IEEE Transactions On Reliability*, 59(1), pp.242-249.
<https://doi.org/10.1109/TR.2010.2041972>.