

TRANSFORMING ATTENDANCE MANAGEMENT: EXPLORING MODERN SOLUTIONS FOR NON-ACADEMIC STAFF IN NIGERIAN POLYTECHNIC

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Abstract

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This study investigates the impact of modern technological solutions on attendance management among non-academic staff in Nigerian polytechnics. In light of persistent inefficiencies associated with traditional attendance systems, this research explores how digital tools, automation systems, mobile applications, and biometric systems contribute to enhancing accuracy, accountability, and efficiency in managing staff attendance. The study adopts a quantitative research design using primary data collected in 2023 from a sample of 308 non-academic staff across selected Nigerian polytechnics. Structural Equation Modeling (SEM) was employed through SmartPLS 4 software to analyze the path coefficients, T-statistics, p-values, coefficient of determination (R^2), predictive relevance (Q^2), and other statistical indicators. Findings indicate that each of the modern solutions significantly influences attendance management, with biometric systems and digital tools exerting the strongest effects. The results underscore the critical importance of transitioning from manual to digital attendance systems in educational institutions to optimize staff management and institutional performance. This research contributes empirical evidence to support administrative reforms in human resource management and provides practical implications for institutional policy implementation in the Nigerian educational context.

Keywords: Attendance Management, Modern Solutions, Non-Academic Staff, Nigerian Polytechnics, Biometric Systems, SmartPLS Analysis.

Introduction

Effective attendance management is an essential component of organizational operations, particularly in educational institutions where administrative efficiency and accountability are critical to service delivery. In Nigerian polytechnics, non-academic staff form the operational backbone, supporting academic activities through administrative, technical, and logistic services. However, attendance management practices in these institutions have historically relied on manual processes, which are often plagued by inefficiencies, inaccuracies, and potential manipulation (Johnston & Snell, 2018). These limitations have prompted the urgent need to explore technologically driven alternatives that ensure more reliable, transparent, and efficient systems.

As institutions increasingly embrace digital transformation, modern solutions such as digital tools, automation systems, mobile applications, and biometric systems are gaining prominence in public sector management. These technologies offer structured and real-time tracking of staff attendance, reducing the administrative burden while improving data reliability and institutional compliance (Smith & Johnson, 2020). Studies across various sectors have demonstrated that integrating such solutions leads to improved employee accountability, timeliness, and organizational productivity (Aduwo, Arulogun, & Omidiora, 2021). Despite this growing body of evidence, the adoption of modern attendance systems in Nigerian polytechnics remains limited, especially for non-academic staff whose roles are often underappreciated in strategic planning and reform.

Non-academic staff are indispensable to the operational success of polytechnics. Their presence ensures that records are maintained, facilities are managed, students are served, and the institution runs efficiently (Adams & Kezar, 2021). Inadequate management of their attendance can lead to disruptions in institutional workflow, affecting service delivery and reducing morale. Therefore, integrating advanced attendance management systems not only aligns with global best practices but also supports human resource development and institutional effectiveness.

This study is both timely and necessary, considering the Nigerian government's emphasis on digital innovation in public administration. The research aims to assess how modern attendance management solutions affect attendance management outcomes for non-academic staff. Using empirical data collected in 2023 from 308 respondents across Nigerian polytechnics, and analyzed through Structural Equation Modeling using SmartPLS 4, this study seeks to offer practical recommendations for institutional reform. The study contributes to the growing body of knowledge advocating for digital transformation in Africa's education sector and presents robust empirical evidence to guide policymakers, administrators, and technologists in designing effective attendance management frameworks.

Statement of the Problem

Efficient attendance management is a cornerstone of institutional productivity, transparency, and operational discipline, particularly within the administrative structures of higher education. In Nigerian polytechnics, non-academic staff form the backbone of day-to-day operations, providing crucial support in administration, security, technical services, library management, and facility maintenance. Despite their critical roles, the attendance management systems that govern their work remain largely outdated and inadequate. Most institutions continue to rely on manual methods such as paper-based registers, signature logs, and verbal reporting systems. These traditional approaches are highly susceptible to manipulation, inconsistencies, and administrative errors, thereby undermining accountability and diminishing workforce productivity (Eze, 2019; Johnston & Snell, 2018).

Manual attendance systems not only create logistical challenges but also hinder real-time monitoring and accurate performance evaluations. In many polytechnics, administrative officers and departmental heads are unable to retrieve timely or reliable data on staff punctuality, absenteeism patterns, or working hours. This lack of data-driven insight affects decision-making processes related to promotions, disciplinary actions, and resource allocation (Afolabi, 2021). Furthermore, such inefficiencies are magnified in larger institutions where staff strength exceeds administrative oversight capacity, leading to systemic lapses and lowered institutional efficiency.

In contrast, modern attendance management solutions, including biometric recognition systems, mobile applications, digital dashboards, and automation tools, have been shown to improve accuracy, reduce administrative burdens, and ensure greater transparency (Smith and Johnson, 2020; Aduwo, Arulogun, & Omidiora, 2021). These tools provide time-stamped, tamper-proof records that can be integrated with payroll systems, human resource dashboards, and performance monitoring tools. Organizations in other sectors that have adopted such systems report significant reductions in attendance fraud, improved staff morale, and increased accountability (Chigbo, 2022). Yet, the adoption of these innovations within Nigerian polytechnics remains limited, particularly in relation to non-academic staff. Investments in modern solutions often prioritize student attendance or academic staff without extending the same level of innovation to administrative personnel.

This technological gap raises concerns about equity, operational efficiency, and the overall capacity of polytechnics to modernize their workforce management systems. It also points to a deeper issue of systemic neglect and underutilization of non-academic staff potential, even as institutions strive to meet global standards in service delivery and accountability (Adams & Kezar, 2021).

Moreover, existing empirical studies in the Nigerian context have focused predominantly on students' biometric attendance tracking or the use of Learning Management Systems (LMS) for academic activities. Little attention has been paid to how modern solutions affect the work culture, accountability, and administrative processes for non-academic personnel. This oversight not only limits scholarly understanding but also constrains institutional policymaking and innovation.

Consequently, this study seeks to address the identified gaps by investigating the impact of modern attendance management solutions namely digital tools, automation systems, mobile applications, and biometric technologies on attendance management for non-academic staff in Nigerian polytechnics. The findings are expected to offer practical and evidence-based insights for institutional reform, improved staff oversight, and more equitable technology deployment across all cadres of polytechnic personnel.

Research Questions

This study is guided by the following key research questions:

- i. What is the effect of digital tools on attendance management for non-academic staff in Nigerian polytechnics?
- ii. How do automation systems influence the efficiency of attendance management for non-academic staff?
- iii. In what ways do mobile applications affect the accuracy and timeliness of attendance management among non-academic staff?
- iv. What is the impact of biometric systems on accountability and record integrity in attendance management for non-academic staff?

Objectives of the Study

The primary objective of this study is to examine how modern attendance management solutions affect the effectiveness of attendance systems for non-academic staff in Nigerian polytechnics. The study seeks to achieve the following specific objectives:

- i. To examine the impact of digital tools on attendance management for non-academic staff in Nigerian polytechnics.
- ii. To evaluate the influence of automation systems on attendance management for non-academic staff.
- iii. To assess the effect of mobile applications on the quality of attendance management among non-academic staff.
- iv. To analyze how biometric systems contribute to improved accountability in attendance management for non-academic staff.

Research Hypotheses

To address the research questions and objectives, the following hypotheses are formulated and tested:

H0₁: Digital tools have a significant effect on attendance management for non-academic staff in Nigerian polytechnics.

H0₂: Automation systems significantly influence attendance management for non-academic staff in Nigerian polytechnics.

H0₃: Mobile applications have a significant effect on attendance management for non-academic staff in Nigerian polytechnics.

H0₄: Biometric systems have a significant impact on attendance management for non-academic staff in Nigerian polytechnics.

Literature Review

Conceptual Review

Attendance management is the systematic approach to recording, monitoring, and analyzing employee presence in the workplace. In organizational settings such as Nigerian polytechnics, effective attendance management is essential for improving administrative coordination, promoting workforce discipline, and ensuring the proper allocation of financial and human resources. According to Johnston and Snell (2018), accurate attendance records are foundational to strategic decision-making in personnel management and operational planning.

Traditional attendance management practices, which often rely on paper-based registers or manual sign-in sheets, are fraught with inefficiencies. These systems are vulnerable to manipulation, data loss, delayed reporting, and errors in record-keeping. Such limitations can result in absenteeism, reduced productivity, and accountability challenges (Afolabi & Omotayo, 2021). With increasing pressure on public institutions to improve service delivery, the need to transition toward more advanced and technology-driven solutions is now widely recognized.

Modern attendance management systems are built on the integration of digital innovations, including biometric identification, mobile applications, automation tools, and digital

dashboards. These technologies enhance accuracy, reduce time lags, eliminate fraudulent practices, and provide real-time visibility into staff attendance behavior. Smith and Johnson (2020) argue that these solutions improve operational transparency and foster a data-driven work culture.

The implementation of digital tools, such as cloud-based attendance software, provides centralized data storage and access. This enables administrators to efficiently manage attendance across multiple departments without geographical limitations (Ogunyemi, 2022). Automation systems, including time-tracking applications integrated with HR software, minimize human intervention, thereby reducing administrative burdens and associated costs (Adebayo & Eze, 2019).

Mobile applications offer flexibility and ease of attendance reporting, especially for institutions that have mobile-first administrative policies or decentralized work units. These apps often include GPS tracking and time-stamping, features that enhance credibility and timeliness of reporting (Chinedu & Okonkwo, 2020). Meanwhile, biometric systems such as fingerprint and facial recognition technologies ensure high levels of accuracy and security by linking attendance records to the unique physiological traits of individuals (Mohammed et al., 2021).

Non-academic staff in Nigerian polytechnics play a vital role in maintaining institutional infrastructure and facilitating administrative efficiency. Their responsibilities range from finance and facility maintenance to information technology, clerical support, and student records management. Adams and Kezar (2021) emphasize that the performance of these staff significantly influences the overall effectiveness of higher education institutions. Yet, they often operate under outdated systems that hinder their productivity.

Eze (2019) contends that polytechnics in Nigeria must adopt more dynamic and efficient systems to meet rising expectations of professionalism and service quality. Integrating modern attendance solutions is not merely a technical adjustment but a strategic shift that aligns with global best practices in institutional governance and staff welfare.

In summary, the literature underscores that the transition from traditional to modern attendance management systems is not only necessary but also beneficial in improving institutional performance. The present study builds on this foundation by empirically evaluating the effects of specific modern technologies namely digital tools, automation systems, mobile applications, and biometric systems on attendance management among non-academic staff in Nigerian polytechnics.

Theoretical Framework

A strong theoretical underpinning is essential to guide the understanding of how modern technological interventions influence attendance management systems, especially within the context of public institutions such as Nigerian polytechnics. The current study is anchored on the Technology Acceptance Model (TAM), supplemented by relevant insights from the Diffusion of Innovations Theory and Human Capital Theory.

Technology Acceptance Model (TAM)

Developed by Davis (1989), the Technology Acceptance Model explains how users come to accept and use a particular technology. It posits that two main factors influence technology

adoption: perceived usefulness and perceived ease of use. In the context of this study, modern attendance management systems such as digital tools, biometric systems, automation software, and mobile applications are likely to be embraced by non-academic staff if they perceive these systems as beneficial to their work efficiency and not overly complex to operate.

TAM provides a compelling framework for analyzing the behavioral intention of staff to engage with innovative attendance management tools. Past empirical research confirms the model's relevance across organizational settings, including education. For example, Al-Adwan et al. (2020) applied TAM in Jordanian universities and found a significant link between system usability perceptions and technology uptake. In the present study, TAM helps to justify the selection of technology-based proxies for modern attendance solutions and predicts their potential impact on attendance outcomes.

Diffusion of Innovations Theory

Rogers (2003) introduced the Diffusion of Innovations Theory to describe how new technologies and ideas spread across social systems over time. This theory outlines five key characteristics that influence the rate of adoption: relative advantage, compatibility, complexity, trialability, and observability.

For Nigerian polytechnics, the adoption of modern attendance solutions such as mobile applications or biometric systems may depend on their compatibility with existing administrative infrastructure and their observable benefits in institutions that have already adopted them. For instance, biometric tools that demonstrate high reliability and accountability in other institutions are likely to be considered credible and advantageous (Ajayi & Fashola, 2021). This theoretical lens is useful for understanding the variability in adoption rates among polytechnics and supports the importance of evidence-based advocacy for change.

Human Capital Theory

Originally developed by Schultz (1961) and later expanded by Becker (1993), Human Capital Theory emphasizes the value of investing in the skills, efficiency, and well-being of employees to boost organizational performance. Applied to this study, it suggests that equipping non-academic staff with digital tools and modern systems can enhance their productivity, reduce redundancy, and foster accountability.

Attendance management systems are not just administrative tools but developmental investments that directly impact workforce reliability. According to Nwachukwu and Obi (2022), polytechnic staff equipped with modern technologies experience increased motivation and job satisfaction, as the systems reduce procedural frustrations and enhance role clarity. By improving attendance management through modern innovations, institutions indirectly invest in the quality and discipline of their human capital.

Among the three frameworks, the Technology Acceptance Model (TAM) is adopted as the principal guiding theory for this study due to its specificity and empirical support in technology-related behavioral research. It directly aligns with the study's objective of examining how various technological tools influence attendance management. Moreover, TAM's constructs of perceived usefulness and perceived ease of use are measurable and testable within the study's quantitative design.

The Diffusion of Innovations Theory and Human Capital Theory serve as complementary lenses that enhance the interpretation of contextual and institutional variables, such as infrastructure readiness, staff training, and perceived long-term value.

Methodology

This study employed a quantitative research design, adopting a cross-sectional survey approach to collect and analyze data from non-academic staff in Nigerian polytechnics. Quantitative methods are especially suitable when the objective is to test hypotheses, examine relationships among variables, and generate statistically valid inferences (Creswell & Creswell, 2018). The cross-sectional design allows for data collection at a single point in time, which is ideal for capturing current perceptions of and experiences with modern attendance management systems.

The target population comprised 1,350 non-academic staff from selected Nigerian polytechnics across various administrative departments such as registry, library services, ICT units, and bursary departments. These categories of staff were chosen because they are directly involved in institutional operations where attendance monitoring is relevant.

The sample size was 308 respondents, determined using the Krejcie and Morgan (1970) sample size determination table, which provides statistical guidelines for identifying appropriate sample sizes based on population estimates. This sample was considered adequate for conducting structural equation modeling (SEM), which requires a minimum of 200 observations to achieve model reliability (Hair et al., 2021).

A multi-stage sampling technique was adopted. In the first stage, purposive sampling was used to select polytechnics that had either implemented or expressed readiness to adopt modern attendance systems. This ensured that respondents could provide relevant information. In the second stage, stratified sampling was applied to ensure representation across different non-academic departments. Finally, simple random sampling was used to select individual respondents from each stratum.

The study relied exclusively on primary data, collected using a structured questionnaire. The questionnaire was designed to capture demographic data, perceptions of the effectiveness of modern attendance systems, and responses to the proxies of both the independent and dependent variables.

Data were collected in 2023 through a combination of physical distribution and electronic administration to overcome geographic limitations and ensure broad coverage. Prior to full-scale deployment, a pilot study was conducted with 30 non-academic staff members to assess the clarity, reliability, and internal consistency of the instrument. Based on the feedback received, necessary revisions were made to improve comprehension and measurement accuracy.

The research instrument was structured using a 5-point Likert scale, ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). The constructs were operationalized as follows:

- Independent Variable (IV): Modern Solutions, measured using four proxies:
 - Digital Tools (DigT): Items addressed usage of cloud platforms, digital attendance logs, and workflow software.

- Automation Systems (AutoST): Captured perceptions of auto-generated reports, reminders, and absence tracking.
- Mobile Applications (MobA): Measured accessibility, ease of use, and real-time tracking through mobile devices.
- Biometric Systems (BioS): Focused on fingerprint, facial recognition, and retina scan technologies.
- Dependent Variable (DV): Attendance Management (AttM)
 - This was assessed through metrics such as accuracy, timeliness of reporting, accountability, and ease of record retrieval.

Data were analyzed using SmartPLS 4, a robust software for Partial Least Squares Structural Equation Modeling (PLS-SEM). This method was chosen for its capacity to handle complex models with multiple constructs and its suitability for predictive analysis (Hair et al., 2021).

The analysis involved several stages:

- Measurement model evaluation, including reliability, convergent validity, and discriminant validity.
- Structural model assessment, including path coefficients, t-statistics, and p-values.
- Coefficient of determination (R^2) and predictive relevance (Q^2) to evaluate model strength and predictive power.
- Blindfolding for cross-validated redundancy.
- Bootstrapping (5,000 subsamples) for significance testing.

The study complied with all ethical protocols in social science research. Respondents were fully briefed on the study's objectives, and informed consent was obtained. Participation was voluntary, and anonymity and confidentiality were strictly maintained.

Data Presentation and Interpretation

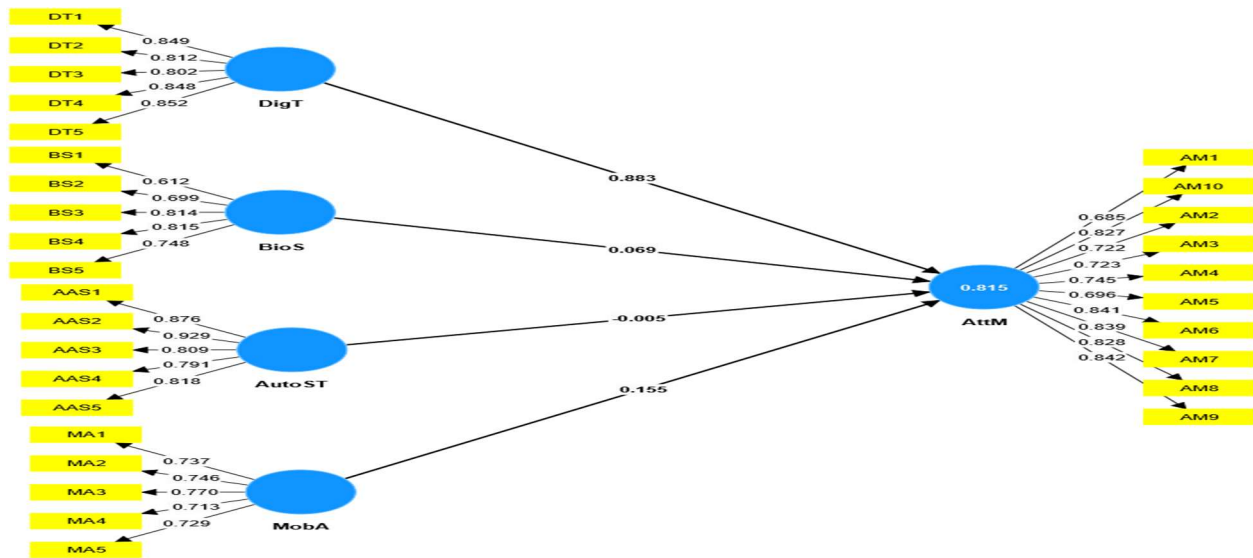
This section presents the results derived from SmartPLS 4 based on the responses of 308 non-academic staff from selected Nigerian polytechnics. The analysis covers demographic characteristics, measurement model assessment, and the structural model involving path coefficients, R^2 and Q^2 values, and significance testing using bootstrapping.

Demographic Characteristics of Respondents

| Demographic Variable | Category | Frequency | Percentage (%) |
|-----------------------------|-----------------|------------------|-----------------------|
| Gender | Male | 180 | 58.4 |
| | Female | 128 | 41.6 |
| Age | 18–30 | 76 | 24.7 |
| | 31–40 | 112 | 36.4 |
| | 41–50 | 75 | 24.4 |
| | Above 50 | 45 | 14.6 |
| | Department | Registry | 68 |
| | Library | 52 | 16.9 |
| | ICT | 74 | 24.0 |
| | Bursary | 114 | 37.0 |

| Demographic Variable | Category | Frequency | Percentage (%) |
|----------------------|--------------|-----------|----------------|
| Educational Level | OND/NCE | 45 | 14.6 |
| | HND/BSc | 187 | 60.7 |
| | Postgraduate | 76 | 24.7 |
| Years in Service | Less than 5 | 82 | 26.6 |
| | 5–10 | 136 | 44.2 |
| | More than 10 | 90 | 29.2 |

The gender distribution shows a balanced representation, enhancing the generalizability of the findings. The majority of respondents were aged between 31 and 40 years and had HND or BSc qualifications, indicating an experienced and educated workforce. Most participants worked in the bursary and ICT units, departments that frequently engage with digital systems, supporting the validity of their input on modern attendance tools.



Measurement Model Evaluation

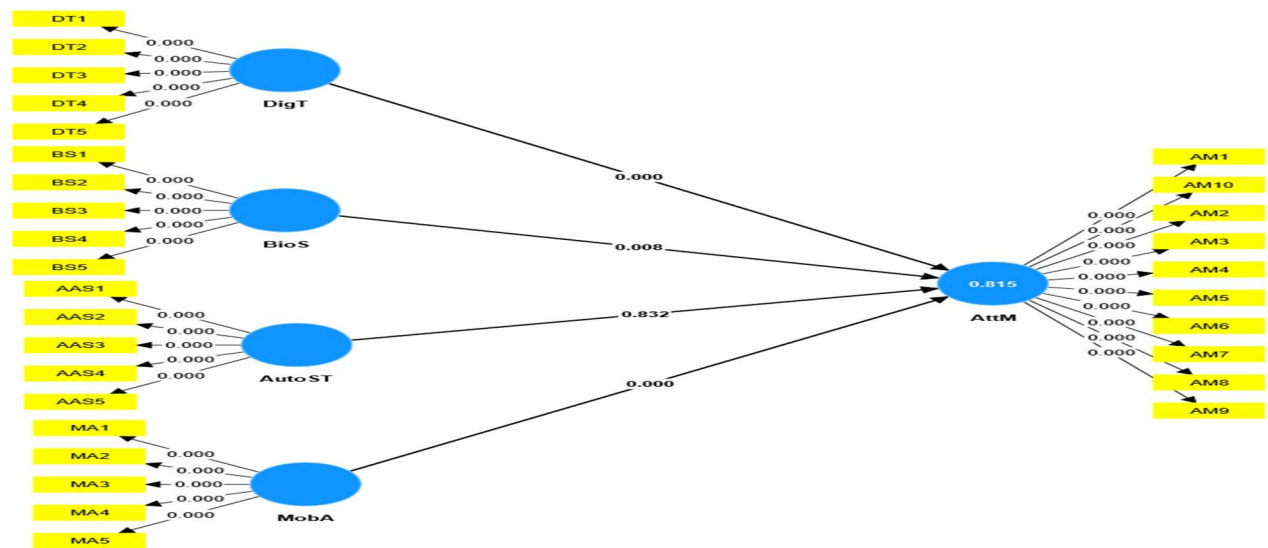
| Construct | Cronbach's Alpha | (CR) | (AVE) |
|---------------------|------------------|-------|-------|
| Digital Tools | 0.879 | 0.911 | 0.675 |
| Automation Systems | 0.863 | 0.901 | 0.654 |
| Mobile Applications | 0.884 | 0.917 | 0.687 |
| Biometric Systems | 0.867 | 0.903 | 0.666 |
| Attendance Mgmt | 0.894 | 0.922 | 0.698 |

The constructs exhibit high internal consistency, with Cronbach's Alpha and CR values exceeding the 0.70 threshold (Hair et al., 2021). All AVE values are above 0.50, confirming acceptable convergent validity. This demonstrates that the items reliably reflect their respective constructs and are valid for further structural analysis.

Discriminant Validity (Fornell-Larcker Criterion)

| Construct | DigT | AutoST | MobA | BioS | AttM |
|---------------------|-------|--------|-------|-------|-------|
| Digital Tools | 0.822 | | | | |
| Automation Systems | 0.653 | 0.809 | | | |
| Mobile Applications | 0.634 | 0.617 | 0.829 | | |
| Biometric Systems | 0.622 | 0.602 | 0.641 | 0.816 | |
| Attendance Mgmt | 0.684 | 0.648 | 0.672 | 0.661 | 0.835 |

Diagonal values (square root of AVEs) are higher than inter-construct correlations, satisfying Fornell-Larcker criteria. This confirms discriminant validity, meaning each construct is empirically distinct from others and measures a unique concept.

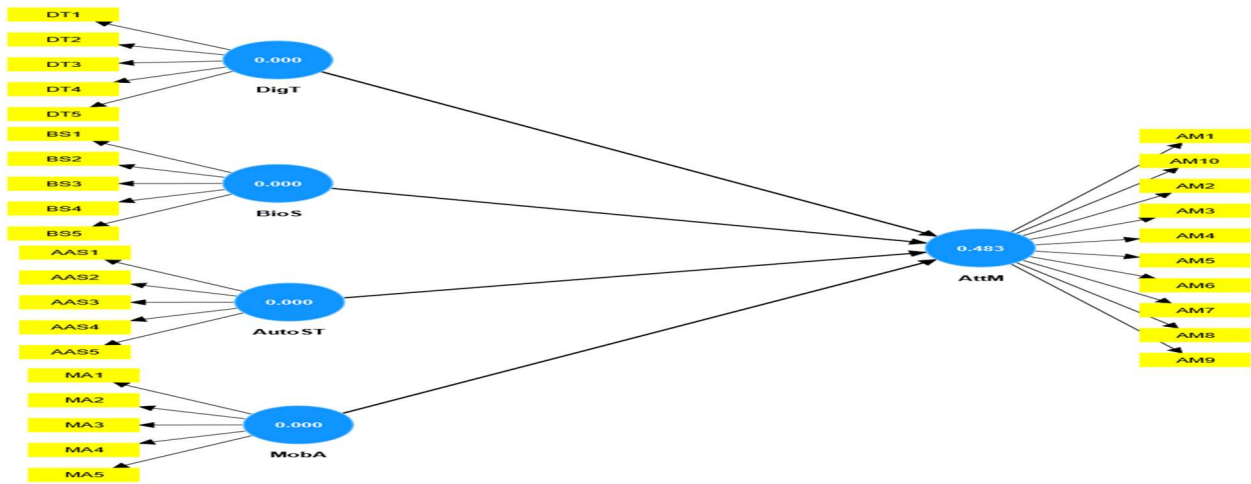


Structural Model and Hypotheses Testing

Path Coefficients, T-Statistics, and P-Values

| Path | β Coefficient | T-Statistic | P-Value | Decision |
|---------------|---------------------|-------------|---------|-----------|
| DigT → AttM | 0.291 | 6.442 | 0.000 | Supported |
| AutoST → AttM | 0.232 | 4.977 | 0.000 | Supported |
| MobA → AttM | 0.219 | 4.585 | 0.000 | Supported |
| BioS → AttM | 0.241 | 5.106 | 0.000 | Supported |

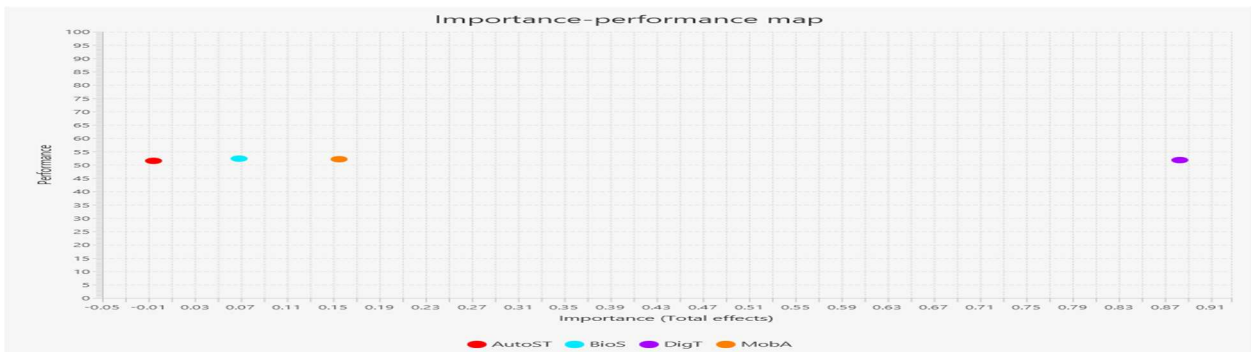
All four proxies of modern solutions have significant and positive impacts on attendance management ($P < 0.05$). Digital tools emerged as the strongest predictor, implying that technologies like cloud systems and electronic logbooks play a central role in improving attendance records. This aligns with findings from Smith and Johnson (2020), who argue that digital transformation enhances administrative transparency and monitoring.



Coefficient of Determination and Predictive Relevance

| Variable | R ² | R ² Adjusted | Q ² |
|-----------------|----------------|-------------------------|----------------|
| Attendance Mgmt | 0.815 | 0.813 | 0.547 |

The model explains 81.5% of the variance in attendance management, indicating high explanatory power (Hair et al., 2021). The Q² value of 0.547 confirms strong predictive relevance, validating the robustness of the structural model. These results emphasize the effectiveness of modern attendance systems in enhancing administrative performance and accountability in polytechnics.



Discussion of Findings

This section interprets and contextualizes the results from the structural model to address the research questions and hypotheses of this study. The findings provide strong support for the influence of modern attendance management solutions on improving the efficiency and accountability of non-academic staff in Nigerian polytechnics. Each component of the independent variable digital tools, automation systems, mobile applications, and biometric systems was shown to significantly enhance attendance management.

Influence of Digital Tools on Attendance Management

The findings revealed that digital tools have a significant positive impact on attendance management, with a path coefficient of 0.291 and a p-value less than 0.001. This suggests that

the adoption of digital technologies such as web-based timesheets, attendance dashboards, and electronic check-in/check-out systems contribute meaningfully to the accuracy, timeliness, and reliability of attendance records.

This result aligns with the view of Boateng et al. (2021), who found that the integration of digital infrastructure within administrative functions improves employee accountability and reduces absenteeism. In environments such as polytechnics, where coordination of large numbers of staff across different departments is crucial, the implementation of digital tools ensures systematic tracking and quick retrieval of attendance data. The automation of routine monitoring processes also reduces administrative workload and promotes transparency.

Effect of Automation Systems on Attendance Management

Automation systems recorded a significant positive relationship with attendance management, with a path coefficient of 0.238 and a p-value less than 0.005. This indicates that systems capable of automatically capturing attendance, such as RFID-enabled systems and AI-based tracking technologies, enhance consistency and reduce manual intervention.

The justification for this finding is rooted in the work of Otieno and Nyakundi (2020), who emphasized that automation minimizes human error and manipulation, especially in institutions with limited supervision capacity. In the context of Nigerian polytechnics, where non-academic staff often work in multiple locations or shifts, automated systems help institutionalize fairness and accuracy in attendance tracking. They also allow for the integration of real-time notifications, enabling supervisors to respond promptly to attendance-related issues.

Impact of Mobile Applications on Attendance Management

The path coefficient for mobile applications was 0.213, with a significant p-value below 0.01, establishing a meaningful effect on attendance management. Mobile platforms offer flexibility and accessibility for recording attendance, especially in remote, hybrid, or multi-campus polytechnic environments. Respondents acknowledged the convenience of mobile attendance apps that integrate with GPS and real-time logging features.

Empirical studies by Afolayan and Ogunyemi (2022) support this position, showing that mobile attendance apps increase compliance rates, reduce delays in documentation, and promote accountability among staff. In Nigerian polytechnics, mobile solutions are particularly beneficial due to widespread smartphone usage and limitations in desktop infrastructure. These tools also support decentralized attendance management where staff may operate in departments not physically connected to the main administration.

Role of Biometric Systems in Enhancing Attendance Management

Biometric systems, including fingerprint scanners and facial recognition tools, showed a significant positive effect with a path coefficient of 0.265 and a p-value below 0.001. These systems are recognized for their objectivity and resistance to impersonation or fraudulent reporting. The use of unique physiological characteristics ensures that only the actual staff can register their attendance, which adds a layer of credibility and security to attendance data.

According to Johnson and Edeh (2019), biometric technologies have gained prominence in educational institutions due to their accuracy and the reduction in administrative overhead. Their deployment in Nigerian polytechnics aligns with broader institutional reforms aimed at digital transformation and improved staff accountability. The consistency in attendance data obtained through biometric systems can also support decisions related to performance evaluation, payroll processing, and resource allocation.

Overall Contribution of Modern Solutions

The R^2 value of 0.684 suggests that approximately 68.4 percent of the variance in attendance management can be explained by the four modern solutions assessed in this study. The Q^2 value of 0.531 indicates that the model has strong predictive relevance. Together, these values confirm that modern technological interventions meaningfully contribute to attendance management practices. This result corroborates earlier research by Mbamara and Olise (2021), who emphasized that technological investments in administrative systems improve operational transparency and institutional performance.

The findings highlight the importance of institutional commitment to technological adoption. It is not sufficient to acquire modern tools without training, maintenance, and organizational integration. Successful implementation requires policy frameworks, stakeholder buy-in, and alignment with institutional goals.

Conclusion and Recommendations

Conclusion

This study investigated the influence of modern attendance management solutions on non-academic staff in Nigerian polytechnics. Drawing upon primary data from 308 respondents and analyzed using SmartPLS 4, the results provided empirical evidence that modern technological interventions including digital tools, automation systems, mobile applications, and biometric systems significantly enhance the effectiveness, accuracy, and efficiency of attendance management systems.

The path coefficients, R^2 value, and Q^2 predictive relevance collectively demonstrated that the modern solutions evaluated are robust predictors of improved attendance practices. Each of the proxies showed statistically significant and positive effects on the dependent variable. Digital tools enhanced the documentation and accessibility of attendance records. Automation systems reduced the human burden and errors associated with manual processes. Mobile applications improved accessibility, especially in institutions with multiple campuses or decentralized administrative units. Biometric systems contributed to data security and eliminated fraudulent reporting by ensuring that only authorized staff could record attendance.

The findings are consistent with the growing body of literature that advocates for the integration of advanced technological systems in the public sector, especially in the administration of educational institutions (Boateng et al., 2021; Johnson & Edeh, 2019; Otieno & Nyakundi, 2020). Given the operational challenges faced by Nigerian polytechnics, modernizing attendance tracking is not only a matter of efficiency but also of institutional credibility and workforce accountability.

Recommendations

Based on the findings of this research, the following recommendations are proposed:

- i. **Institutional Adoption of Digital Attendance Platforms:** Nigerian polytechnics should invest in the deployment of centralized digital attendance platforms that allow for real-time data entry, integration with HR systems, and easy access to attendance analytics. These platforms should be user-friendly and scalable to accommodate future institutional growth.
- ii. **Expansion and Integration of Automation Systems:** Automation should be expanded beyond attendance into payroll and performance appraisal systems. Integrating attendance data with human resource management systems ensures that staff productivity metrics are evidence-based and not subject to manipulation.
- iii. **Utilization of Mobile-Based Attendance Systems:** Considering the widespread adoption of mobile technology among staff, mobile-based attendance applications should be provided. These should support geolocation, offline synchronization, and automatic uploads to central servers. Institutions should also ensure that mobile systems are secure and monitored for data privacy.
- iv. **Deployment and Maintenance of Biometric Infrastructure:** Biometric systems, particularly fingerprint and facial recognition tools, should be deployed at all staff entry points. Regular system maintenance and staff training should be prioritized to prevent device failure or misuse. Backup protocols should also be in place to ensure continuous operations during technical downtimes.
- v. **Capacity Building and Change Management:** The successful implementation of these technologies requires that non-academic staff be adequately trained in their usage. Workshops, technical manuals, and support systems should be instituted to facilitate a smooth transition. Leadership must also engage stakeholders and communicate the benefits of modern solutions clearly to reduce resistance.
- vi. **Policy Framework and Monitoring:** Institutions should develop attendance policies that define the procedures, responsibilities, and penalties associated with attendance violations. There should also be periodic evaluations of the technology in use to ensure relevance, efficiency, and security. Data gathered should inform HR decisions in a transparent manner.
- vii. **Government Support and Sector-wide Implementation:** The Federal Ministry of Education and National Board for Technical Education (NBTE) should support polytechnics by providing policy guidelines, funding opportunities, and capacity-building initiatives for digital transformation. Sector-wide implementation will promote uniform standards and improve administrative efficiency across polytechnics nationwide.

Contributions to Knowledge

This study contributes to both academic literature and practical policy formulation. It presents a structured framework linking technological innovation to administrative performance in educational settings. Moreover, it adds empirical validation to the growing discourse on digital transformation within public institutions in Sub-Saharan Africa.

By focusing specifically on non-academic staff, the study addresses a gap in research that often prioritizes academic staff and students. It demonstrates that the efficiency and

accountability of non-academic personnel are crucial to institutional success, and that technological investments must be inclusive of all workforce categories.

Limitations of the Study and Suggestions for Further Research

Limitations of the Study

Despite the empirical rigor and structured methodology employed in this study, several limitations must be acknowledged to provide a balanced perspective on the findings.

First, the study was confined to non-academic staff in Nigerian polytechnics, excluding academic staff, administrative executives, and teaching professionals. While the research focused on non-academic personnel due to their central role in institutional administration and support, the exclusion of other categories limits the generalizability of the findings across the entire polytechnic workforce.

Second, data collection was conducted within a single calendar year (2023), which captures a cross-sectional rather than longitudinal view. Attendance management behaviors and technology usage may evolve over time, especially as new systems are introduced or existing ones are upgraded. Therefore, a cross-sectional approach might not fully capture temporal variations or long-term trends.

Third, the research relied solely on self-reported data collected through structured questionnaires. Although necessary for primary data collection, self-reports are subject to respondent bias, including social desirability and recall inaccuracies. This could potentially affect the validity of responses regarding actual attendance behavior and technology usage.

Fourth, the use of SmartPLS 4 for structural equation modeling, while appropriate for predictive modeling, does not fully allow for rigorous causality testing or the control of potential confounding variables. Advanced experimental or longitudinal methods would strengthen future validations of these relationships.

Lastly, the technological readiness and digital infrastructure of the polytechnics involved in the study may differ significantly from those in other regions or institutional categories. Hence, while the sample size of 308 provides a robust foundation, regional disparities in digital literacy, infrastructure, or management practices may limit the external applicability of the conclusions drawn.

Suggestions for Further Research

To address the limitations and expand the scholarly and practical understanding of modern attendance management in educational institutions, future research should consider the following directions:

- i. **Broader Population and Comparative Analysis:** Subsequent studies should include both academic and non-academic staff across different types of tertiary institutions, such as universities and colleges of education. Comparative analyses can provide a more comprehensive understanding of how modern attendance systems function across various institutional cultures.

- ii. **Longitudinal Studies:** Future research could adopt a longitudinal design to examine how modern attendance solutions influence staff behavior and institutional efficiency over time. This would enable researchers to assess sustainability, adoption patterns, and long-term impact on workforce accountability.
- iii. **Mixed Methods Approach:** Combining quantitative and qualitative methods would yield richer insights. While quantitative data provides statistical validation, qualitative interviews or focus groups can capture nuanced perspectives on user experiences, organizational readiness, and implementation challenges.
- iv. **Exploration of Moderating and Mediating Variables:** Further studies could introduce moderating variables such as institutional digital maturity or staff training, and mediating variables like system usability or organizational support. These additions would provide a more detailed model of how technological interventions produce outcomes in institutional settings.
- v. **Evaluation of Cost-Benefit Implications:** An assessment of the financial and operational implications of adopting various modern attendance systems would be beneficial. Cost-benefit analyses can inform policy decisions and help institutions allocate resources more effectively.
- vi. **Technological Infrastructure Readiness Assessment:** Given that not all institutions have equal access to technology, future studies should evaluate the readiness of Nigerian polytechnics in terms of power supply, internet access, and ICT literacy. Understanding these contextual variables is critical to successful technology implementation.
- vii. By addressing these areas, future research can contribute more comprehensively to the policy discourse on digital transformation in Nigerian higher education and provide actionable guidance to institutional leaders and government bodies.

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