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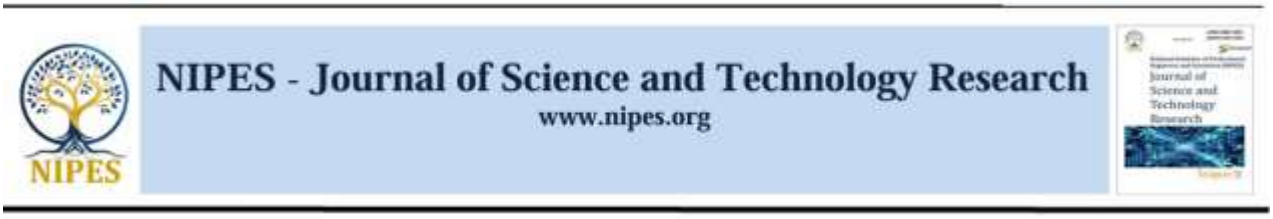

Digital Leadership and Hybrid Learning Effectiveness in Post-Pandemic Education

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Abstract*— Amid the growing shift toward hybrid learning in post-pandemic education, this study examines the influence of digital leadership on hybrid learning effectiveness in Nigerian educational institutions. Drawing on responses from 333 students, the research examines three core dimensions of digital leadership: technology integration (TI), communication and collaboration (CC), and policy development and implementation (PDI). Findings from multiple regression analysis reveal that these dimensions significantly predict hybrid learning effectiveness, collectively accounting for 46.6% of variance in outcomes. Notably, policy development and implementation emerged as the strongest predictor ($\beta = .327$, $p < .001$), underscoring the critical role of leadership in shaping equitable and sustainable digital learning environments. Despite widespread access to digital devices, disparities in internet connectivity persist. This result reinforces the need for inclusive, policy-driven digital leadership to ensure long term success of hybrid learning models in developing contexts.

Keywords: Digital Leadership, Hybrid learning, Educational technology, Policy implementation, Learning outcomes

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I. INTRODUCTION

The COVID-19 pandemic profoundly disrupted education systems worldwide, compelling institutions to adopt hybrid and blended learning modalities across all levels of education [1], [2]. In higher education, this abrupt transition introduced both new opportunities and complex challenges, particularly in ensuring quality, inclusiveness, and sustained student engagement through technology-mediated instruction. Amid this disruption, the role of digital leadership emerged as a cornerstone of institutional resilience and pedagogical innovation. Defined as the strategic, visionary, and adaptive application of technology by educational leaders, digital leadership has increasingly influenced how institutions navigate the digital transformation of teaching and learning [3], [4], [5]. It plays a crucial role not only in shaping faculty adoption of digital tools, but also in framing how students perceive and engage with hybrid learning environments [6].

Yet, despite growing recognition of its importance, the conceptualization and enactment of digital leadership remain fragmented. Scholars such as Karakose et al. [7] and Jameson et al. [8] argue that digital leadership is often conflated with traditional ICT or e-leadership models, lacking a unified theoretical framework. While existing research shows its influence on teachers' technology adoption [9], [10], much of this scholarship remain focused on administrators and educators, offering limited insight into students perceptions and experiences in hybrid learning environments. At the same time, research on hybrid and blended learning from student perspective has uncovered a mixture of enthusiasm and concern. Students appreciate the flexibility and accessibility that hybrid models offer, [11], [12], but often face challenges related to motivation, interaction, and well-being [13]. Importantly, studies suggest that students satisfaction in hybrid learning environments is closely linked to institutional culture, faculty practices, and digital fluency, all of which are influenced by leadership structures [14],[15].

However, current literature frequently treats digital leadership and hybrid learning as separate domains, rarely examining their intersection. Moreover, while instruments like the Digital Leadership Scale (DLS) have advanced the measurement of leadership behaviors [16], they primarily reflect administrator perspectives, with limited application to student-centered evaluations. This gap in theoretical and methodological

integration calls for a more holistic inquiry. Accordingly, this study critically examines students' perceptions of digital leadership and its influence on hybrid learning effectiveness in the post-pandemic context. By bridging leadership and pedagogical domains, the research aims to contribute to ongoing efforts to future-proof education systems through inclusive, student-informed and data-driven approaches to digital transformation.

II. LITERATURE REVIEW

A. Conceptual Evolution of Digital Leadership and Hybrid Learning

The pandemic due to COVID-19 triggered a never-before-seen worldwide shift in education delivery, compelling institutions to make a rapid transition to hybrid and blended models of learning [2], [17]. Besides emergency measures, the models have now become institutionalized within the education sector, necessitating strategic direction, pedagogical innovation, and infusion of technology. At the heart of sense making this new landscape is the question of digital leadership, a form of leadership that spans technology management and transitions into culture-building, foresight, and equity-driven change [18]. Also, at the center is knowing how students consume and experience hybrid learning spaces. Their engagement, satisfaction, and motivation are critical to being positive or negative indicators of the success or failure of hybrid educational interventions. This literature review synthesizes existing literature on digital leadership and hybrid learning, combining conceptual development, empirical findings, and theoretical foundations to provide a unifying framework for subsequent research

B. Digital Leadership in Education: Beyond Technology Management

Digital leadership in education has evolved beyond its initial focus on ICT infrastructure and technical implementation, transforming into a strategic, multidimensional practice that drives institutional innovation, equity, and pedagogical renewal [7], [8]. Early models emphasized infrastructure development and technological adoption. However, ccontemporary literature increasingly positions digital leadership as a vehicle for cultural transformation, fostering faculty empowerment, participatory governance, and systemic change in teaching and learning models [8]. Without consistent conceptualization, the field risks fragmentation, preventing the emergence of unified models that could inform scalable policy and practice

Nevertheless, definitional ambiguities persist: terms like "e-leadership," "technology leadership," and "digital leadership" are often used interchangeably, muddying conceptual clarity [8], [12], [19]. This incoherence hampers cross-study comparisons and weakens theoretical accumulation. Empirical studies robustly affirm the critical role of digital leadership in shaping faculty digital competence and hybrid learning success [3], [11], [11]. Scholars assert that school digital leadership practices accounted for almost 80% of the variance in teachers' technology adoption[9]. Similarly, the Digital Leadership Scale (DLS) developed by scholars captures key dimensions — Innovative Leadership and Supportive Leadership—that predict institutional readiness for digital transformation[4], [16]. However, Jameson et al. caution that many digital leadership initiatives remain technocratic and top-down, failing to empower faculty or students meaningfully[8]. Implying that there is often a strategic disconnect between digital leadership rhetoric and ground-level pedagogical realities

Other empirical studies have identified core variables frequently used to assess digital leadership effectiveness, including technology integration [20], referring to the strategic embedding of digital tools into instructional and administrative processes [21]; communication and collaboration, involving the fostering of transparent, inclusive, and digitally mediated engagement among institutional stakeholders [22]; policy development and implementation, capturing the capacity of educational leaders to design and enforce digital learning policies that promote equity, accessibility, and consistency [23], [24], [25], [26]; visionary and strategic thinking, highlighting a leader's ability to articulate long-term goals and align institutional direction with evolving digital innovation [22], [27]; and digital citizenship promotion, focusing on cultivating ethical, responsible, and safe technology usage among students and staff [28]. These variables collectively provide a multidimensional framework for evaluating the effectiveness and depth of digital leadership within educational settings

C. Hybrid Learning in the Post-Pandemic Era

Hybrid learning, also known as blended learning, combines synchronous and asynchronous instructional approaches to provide flexible, personalized, and engaging learning experiences. The COVID-19 pandemic accelerated its adoption globally [12]. While hybrid learning offers several benefits, such as convenience and accessibility, its success largely depends on the technological infrastructure, pedagogical design, and institutional leadership [4], [19]. In the post-pandemic context, the emphasis has shifted from emergency remote teaching to strategically designed hybrid models that require robust leadership to align instructional strategies with learner needs [29]. Research also highlights the importance of leadership in ensuring the continuity of learning, especially in resource-constrained environments [30].

Students' perceptions are critical indicators of the success of digital transformation initiatives in education. Their feedback offers insight into the usability of learning platforms, the accessibility of resources, and the responsiveness of institutional leadership [31]. Research by [11] shows that perceived ease of use and perceived usefulness—key variables in the Technology Acceptance Model—significantly influence students' satisfaction and engagement in hybrid environments. Additionally, students' attitudes towards digital leadership are shaped by their experiences with communication clarity, tech support, and participatory decision-making [32]. As such, student perception can serve as a barometer for evaluating the

effectiveness of hybrid learning and the capacity of educational leaders to foster inclusive and adaptive digital cultures.

Yu's study of Chinese university students underscores that while many appreciate hybrid flexibility, a significant proportion express concerns over decreased learning quality and require strong self-motivation to succeed [14]. Similarly, [13] find that digital literacy and self-regulation strongly influence learning behavior and satisfaction in hybrid context. . Li et al.'s study, from an academic perspective, adds that hybrid classes show lower levels of participation and motivation compared to traditional face-to-face instruction[11]

The Technology Acceptance Model (TAM), developed by Davis 1989, provides a foundational framework for understanding how users come to accept and use technology. TAM posits that two primary factors—Perceived Usefulness (PU) and Perceived Ease of Use (PEOU)—determine an individual's intention to use a given technological system [33]. TAM which is one of the classical adoption theories, deals with individual level and attitudinal adoption [34]. Therefore, in the context of this study, TAM is particularly relevant in evaluating how students assess the effectiveness of hybrid learning platforms and the leadership strategies driving their implementation. If students perceive the technologies introduced under digital leadership as useful and easy to navigate, they are more likely to engage positively with the hybrid learning environment In an increasingly digitalized, uncertain educational future, digital leadership and hybrid learning design will be central pillars of institutional success. Yet, effectiveness hinges not merely on adopting new technologies, but on cultivating vibrant, inclusive, student-centered learning cultures. Hence, the research posits the following hypotheses:

H_{01}: Technology integration has no significant effect on learning outcomes in hybrid learning environments.

H_{02}: Communication and collaboration have no significant effect on learning outcomes in hybrid learning environments.

H_{03}: Policy development and implementation have no significant effect on learning outcomes in hybrid learning environments

Figure 1: Schematic model of the study

Source: Author's conceptualization (2025)

III. METHODOLOGY

A. *Research Design*

This study adopts a quantitative survey research design to assess the relationship between digital leadership and hybrid learning variables among selected Nigerian university students. This approach is considered suitable for assessing student perceptions across a large population and allows for the generalization of findings *[35]*. A structured questionnaire (5 point Likert scale) was used to collect data, on the indicators of digital leadership and hybrid learning effectiveness, enabling statistical measurement of relationships among the key variables.

B. *Population of the Study*

The population for this study comprises undergraduate students enrolled in hybrid learning environments at one public and one private university in Nigeria. The selected institutions are: Public University A (PU-A) – a leading public university that has implemented hybrid learning infrastructure post-COVID-19, and Private University B (PU-B) – a privately funded institution known for its digital transformative initiatives and established virtual learning ecosystem. The public and private university have approximately 23,000 and 3,500 undergraduate students respectively, bringing the total accessible population to approximately 26,500 for the 2024/2025 academic session.

Sample Size Determination and Justification

To determine the appropriate sample size, Slovin's formula was used. This formula is widely used in survey research to calculate sample size when the total population is known.

$$n = \frac{N}{1 + N(e^2)}$$

Where:
n= required sample size
N= total population (26,500)
e = margin of error (0.05 for a 95% confidence level)
Applying the values:

$$n = \frac{26{,}500}{1 + 26{,}500(0.05^2)}$$

$$n = \frac{26{,}500}{1 + 66.25}$$

$$n = \frac{26{,}500}{67.25}$$

$$n = 394$$

Thus, the required sample size was calculated to be 394 respondents. The survey yielded 333 completed responses, representing a response rate of approximately 85% of the targeted sample. While this falls short of the target sample size, the decision to proceed with the analysis using the obtained sample was based on several methodological considerations. First, the sample had representation across diverse academic levels, providing representation from various stages of the educational journey.

Second, the data showed that majority of the students had access to digital tools and networks which aids with hybrid learning effectiveness. Most importantly, analysis of demographic variables indicated that the obtained sample maintained proportional representation across key demographic dimensions relevant to students' experiences with digital leadership and hybrid learning environments. This demographic diversity strengthens the sample's ability to reasonably approximate the perspectives of the broader student population in relation to digital leadership practices and hybrid learning effectiveness. While acknowledging the limitations of the smaller-than-planned sample size, the robust response rate and representative sample composition provide sufficient basis for meaningful analysis of student perceptions in this context.

C. Instrument Design and Sampling

This study employed a meticulously designed instrument to investigate the relationship between digital leadership and hybrid learning effectiveness in educational settings. The self-administered questionnaire was adapted from established research instruments following a rigorous review of relevant literature. Items measuring digital leadership dimensions were adapted from validated scales developed by Classen et al. (2021) and Abbu et al. (2022), while items assessing hybrid learning effectiveness drew upon the work of Voicu-Dorobantu et al. (2024) and Dikilitas and Rambla (2022) [3], [4], [5], [36]. This approach ensured content validity through the incorporation of previously tested and theoretically grounded measurement items.

The survey contained three sections meant to elicit rich data. The first section collected demographic information from respondents, including age category, gender, level of education, and institutional type, to facilitate the examination of the variables. The second section contained 12 items measuring the primary constructs under investigation. Digital leadership was captured in three dimensions each with three items: technology integration (TI), communication and collaboration (CC), and policy development and implementation (PDI). The efficacy of hybrid learning was assessed through a learning outcomes (LO) subscale. All the items to measure the construct utilized a 5-point Likert scale ranging from "strongly disagree" (1) to "strongly agree" (5) following the research guidelines for measurement from[4].

The study employed a purposive sampling technique to ensure representation from relevant educational institutions. The questionnaire was administered electronically through Google Forms. The questionnaire link was open for over a three-month period within the academic semester, for sufficient time to capture diverse perspectives while maintaining contextual consistency. The digital distribution method facilitated broader geographic reach and accommodated respondents' scheduling preferences, potentially enhancing response rates [16].

D. Data Analysis

Descriptive statistics were computed to summarize respondent characteristics and technology access patterns. Cross-tabulation analysis was performed to examine the distribution of demographic variables and technology access types across the sample. For inferential analysis, multiple linear regression was employed to test the hypothesized relationships between digital leadership dimensions (independent variables) and hybrid learning effectiveness (dependent variable). The regression model was specified as:

$$HLE = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + ... + \beta_n X_n + \varepsilon$$

Where HLE represents hybrid learning effectiveness, $X_1...X_n$ denote the digital leadership dimensions, β_0 is the constant term, $\beta_1...\beta_n$ are the regression coefficients, and ε is the error term.

Prior to main analysis, the psychometric properties of the measurement instrument were assessed through Cronbach's alpha reliability tests to ensure internal consistency of the constructs under investigation. All statistical analyses were performed using IBM SPSS Statistics version 26.

E. Reliability and Validity of Research Instrument

The reliability analysis presented in Table 1 shows a generally strong internal consistency across the measurement scales used in this study.

Table 1: Reliability Statistics

Screen Time Variables	**Cronbach's Alpha**	**N of Items**	**Comment**
Entire Item	**.811**	12	Very good
Technology .Integration (TI)	.847	3	good
Comm. And Collaboration (CC)	.822	3	Good
Policy Dev. And Implementation (PDI)	.806	3	Good
Learning outcomes (LO)	.681	3	Fair

Source: Author's analysis based on survey data (2025).

The overall instrument reliability (α = .811) indicates a consistent measurement tool that effectively captures the intended constructs. The Chrobach's alpha coefficints obtained for the variables including TI (α = .847), CC (α = .822), and PDI (α = .806) show a generally satisfactory reliability levels as refined by *[15]* .

To ensure instrument quality, the questionnaire underwent preliminary validation through expert review by two educational technology specialists and one educational leadership researchers, who assessed face and content validity. Based on their feedback, minor adjustments were made to enhance clarity and contextual relevance.

F. Ethical Consideration

Participation in the study was voluntary, with informed consent obtained from all respondents prior to questionnaire completion. To minimize potential sampling bias, multiple recruitment channels were used, including institutional email lists, professional networks, and educational forums. This multi-channel approach helped ensure adequate representation across demographic variables and institutional contexts.

IV. RESULTS AND DISCUSSION

A. Demographic Data

The demographic and technological access profiles of the students were analyzed using cross-tabulations (see table 2) between the institution types (private vs public) and five key variables age, gender, level of education, access to digital device, and access to internet connectivity.

Table2: Demographic and Technology Access Characteristics by Institution Type

Characteristic	Private Institutions	Public Institutions	Total
Age Distribution			
Under 18	49 (14.7%)	1 (0.3%)	50 (15.5%)
18–21 years	113 (33.9%)	37 (11.1%)	150 (45.0%)
22–25 years	12 (3.6%)	39 (11.7%)	51 (15.3%)
26–30 years	8 (2.4%)	30 (9.0%)	38 (11.4%)
Above 30 years	6 (1.8%)	38 (11.4%)	44 (13.2%)
Gender Distribution			
Female	116 (34.8%)	79 (23.7%)	195 (58.6%)
Male	72 (21.6%)	66 (19.8%)	138 (41.4%)
Education Level			
100 Level	31 (9.3%)	18 (5.4%)	49 (14.7%)
200 level	74 (22.2%)	20 (6.0%)	94 (28.2%)
300 level	41 (12.3%)	28 (8.4%)	69 (20.7%)
400 level	26 (7.8%)	41 (12.3%)	67 (20.1%)
500 level	16 (4.8%)	38 (11.4%)	54 (16.2%)
Digital Device Access			
Yes	173 (52.0%)	138 (41.4%)	311 (93.4%)
No	15 (4.5%)	7 (2.1%)	22 (6.6%)
Internet Connectivity			
Yes	161 (48.3%)	139 (41.7%)	300 (90%)
No	27 (8.1%)	6 (1.8%)	33 (10%)
Total	**188 (56.5%)**	**145 (43.5%)**	**333 (100%)**

Source: Author's field data, analyzed using SPSS (2025).

Age Distribution:

Majority of the respondents aged under 18 (n=49; 14.7%) and between 18-21 years (n=113; 33.9%) were enrolled in the private institution (PU-B), whereas those aged 22 years and above where predominantly from public institution (PU-A). Specifically, the PU-A accounted for 11.7% of respondents aged 22-25, 9.0% of those aged 26-30 and 11.4% of those aged above 30. This age pattern indicates that the private sector accommodates a younger student's cohort, while the public institutions serve more mature student population. The age variation. The age variation has implications for the design and implementation of hybrid learning, as digital leadership approaches must consider the generational differences in digital literacy and learning preferences.

Gender distribution

Out of 195 female respondents, 34.8 were from PU-B and 23.7% were from PU-A. Among the male respondents, (n=138), the distribution was more balanced, with 21.6% and 19.8% attending PU-A and PU-B respectively. This suggests a relatively even gender distribution overall, but a slightly higher female concentration of female students in the PU-B, which may have implications for gender-sensitive approaches in digital sensitive approaches in digital leadership strategies within hybrid learning environment.

Level of Education

The distribution of students across educational levels revealed that lower level respondents (200 and 300 levels) were predominantly in PU-B, while upper-level respondents (400-500 levels) were more concentrated in the PU-A. Specifically, 22.2% of 200-level and 12.3% of 300-level students were enrolled in PU-B, while PU-A has 12.3% of 400-level and 11.4% of 500-level students

Access to Digital Devices

A significant proportion of students reported regular access to digital devices (n=311; 93.4%), with 52.0% from private institutions and 41.4% from public institutions. Only a small fraction of students (n=22; 6.6%) lacked regular access to such devices. This high level of device access indicates a foundational readiness for hybrid learning across both institutional types, affirming the feasibility of device-dependent educational technologies. However, the marginal gaps in access should not be overlooked, as digital leadership must remain inclusive by addressing the needs of students without adequate device access.

Internet Connectivity

Consistent internet access was reported by 300 students (90%), with only 10% lacking connectivity, with 48.3% from PU-B and 41.7% from PU-A. This high level of connectivity represents a positive foundation for implementing hybrid learning approaches. When examining the distribution by institution type, the data reveals relatively similar internet access rates between private and public institutions. Among private institution students, 85.6% report having internet access

(161 out of 188 students), while among public institution students, 95.9% have internet access (139 out of 145 students).

Educational institutions should implement targeted support strategies for the 10% of students lacking internet access, with particular attention to private institutions where the connectivity gap is slightly larger. These institutions should develop hybrid learning resources that can function effectively with intermittent connectivity, including downloadable materials, offline-accessible applications, and alternative submission methods for assignments. Both institution types should consider establishing campus connectivity hubs where students without home internet can access resources, particularly during critical academic periods. The relatively high overall connectivity rate (90%) suggests that hybrid learning initiatives can reasonably incorporate digital components, though with careful attention to ensuring equity for the remaining 10% of students. Policy development should specifically address connectivity requirements for course participation while establishing clear alternative pathways for students with limited access, ensuring that internet connectivity does not become a barrier to educational achievement

B. Hypotheses Testing

Regression Equation:

LO = f (TI + CC + PDI +….e)

Learning Outcomes = 0.885 + 0.198 (TI) + 0.216 (CC) + 0.327 (PDI)

Where LO= Learning Outcomes

TI= Technology Integration

CC= Communication and Collaboration

PDI= Policy Development and Implementation

ε = error margin

Table 3: Predictor Variables' Impact on Learning Outcomes

Predictor	Standardized Coefficients (β)	t	Sig.	Hypotheses Decision
Technology Integration (TI)	0.219	3.434	.001*	Reject H_0
Communication & Coll (CC)	0.221	3.382	.001*	Reject H_0
Policy Development and Implementation (PDI)	0.318	5.188	.000*	Reject H_0
Model Summary	R^2= .466 ; Standard Error = 0.5358			
ANOVA	F (3, 329) = 95.569, p= .000			

Note. * $p <$ .05, β = coefficient value
Source: Author's regression analysis output (2025).

To examine the influence of digital leadership dimensions on students' learning outcomes in a hybrid learning context, a multiple linear regression analysis was conducted using three predictor variables: Technology Integration (TI), Communication and Collaboration (CC), and Policy Development and Implementation (PDI). The results reveal that all the three predictor variables had statisticlly significant relationship with learning outcoomes. TI (β = 0.219, t = 3.434, p = .001): indicates that the integration of digital technologies in the instructional and admisninstrative processess contributes significantly to students' perceived effectiveness of hybrid learning. The null hypothese (H0), which posited no significant relationship is therefore rejected. Communication and Collaboration (β = 0.221, t = 3.382, p = .001): this result implies that the ability of these institutions to foster open digital communication channels and collaborative learning environments significantly predicts positive learning outcomes. This supports the premise that participatory leadership and interaction-rich platforms enhance student engagement and effectiveness. The null hypothesis is also rejected.

Policy Development and Implementation (β = 0.318, t = 5.188, p < .001): shows that this variable had the strongest standardized effect among the predictors, emphasizing the critical role of clear, actionable, and consistently implemented digital policies in shaping student learning experiences. Institutions with robust digital leadership policies are more likely to facilitate effective hybrid learning. The corresponding null hypothesis is also rejected.

The Model explains approximately 46.6% of the variance in learning outcomes (R^2= .466) indicating a moderate to strong predictive power. The standard error of estimate (0.535) reflects a reasonably tight fit between the predictive and observed values, underscoring the model's reliability. Further, the analysis of variance revealed a statistically significant regression model (F (3, 329) = 95.569, p < .001), confirming that the set of predictors collectively explains a significant portion of the variation in students' learning outcomes in a hybrid learning environment.

C. Discussion

The findings from the multiple linear regression analysis provide robust evidence that key dimensions of digital leadership—Technology Integration (TI), Communication and Collaboration (CC), and Policy Development and Implementation (PDI)—are significant predictors of students' learning outcomes within hybrid learning environments. With a model explanatory power of R^2 = 0.466, the results explain approximately 46.6% of the variance in learning outcomes, indicating a strong predictive model for educational contexts transitioning into or operating within digitally mediated instructional systems

The relationship between technology integration and learning outcomes was found to be statistically significant (β =

0.219, p = .001), aligning with earlier research emphasizing the transformative potential of digital technologies in education. Scholars such as [38] assert that the pedagogical application of technology, not just its presence is crucial in enhancing learning outcomes. The positive coefficient implies that institutions which effectively integrate digital tools for both instruction and administration foster greater hybrid learning effectiveness. Furthermore, [31] emphasizes the importance of digital literacy among students and faculty, highlighting that technologically enriched environments promote student autonomy and engagement. However,[18], [39] cautions against over-reliance on technology without corresponding pedagogical strategies. These contrasting perspectives underscore the necessity of a balanced digital leadership approach, one that strategically aligns technology with curriculum and student needs.

For digital economies, this finding signals the need to invest not only in infrastructure (devices, platforms, LMS) but also in strategic digital integration policies that are pedagogically sound. A digitally literate workforce begins with a digitally enriched educational foundation[40].

Communication and collaboration emerged as a significant predictor (β = 0.221, p = .001), reinforcing the centrality of interpersonal dynamics in hybrid learning. The findings corroborate [29], community of Inquiry framework, which highlights social presence and cognitive presence as vital components for meaningful learning in online and blended environments. Effective digital leadership involves fostering transparent communication channels, collaborative virtual spaces, and inclusive decision-making processes. According to [41], the effectiveness of any educational reform, particularly digital innovation rests heavily on relational trust and engagement. Conversely, [42] warn that asynchronous or poorly managed communication in hybrid systems can alienate students, especially those with limited digital skills or internet access. In a digital economy, communication and collaboration are core workforce competencies. Institutions that model these values in hybrid education settings contribute directly to preparing students for digitally networked work environments where collaboration tools (e.g., Slack, Teams, Zoom) and communicative agility are critical

Policy development and implementation showed the strongest influence on learning outcomes (β = 0.318, p < .001), emphasizing the strategic role of governance and institutional commitment to digital transformation. This supports [19], who identified leadership and policy as the most significant enablers of effective educational technology adoption. Policies serve as frameworks for standardizing practices, ensuring equity, and facilitating sustainability. Furthermore, [43] argue that without clearly articulated and well-enforced digital policies, institutions often struggle with fragmented implementation, inefficiencies, and digital exclusion. The strong effect size here suggests that digital leadership is most impactful when it translates into actionable, measurable, and well-communicated institutional policies. This finding underlines the need for system-level leadership that provides clear policy direction on issues such as data privacy, access equity, curriculum digitalization, and teacher training. These policies must be inclusive, context-responsive, and future-oriented

The rejection of all three null hypotheses affirms that digital leadership is a multi-dimensional catalyst for successful hybrid learning. Each dimension contributes uniquely; technology integration provides tools, communication fosters interaction, and policy offers structure.

V. CONCLUSION AND RECOMMENDATION

The study investigated how digital leadership influences hybrid learning effectiveness in Nigerian tertiary institutions. The results confirm that the three dimensions: technology integration, communication and collaboration, and policy development and implementation significantly contributes to students learning outcomes in hybrid learning environments, jointly explaining 46.6% of the observed variance. Among these, ppolicy-making and practice emerged as the most influential factor, underscoring its centrality in structuring effective and sustainable hybrid learning systems. The findings contribution to the educational technology literature by empirical validating the multidimensional nature of digital leadership and highlighting its practical implications for post-pandemic instructional design. They reinforce the need for institutional strategies that integrate infrastructure, ccommunication, and governance to optimize hybrid learning delivery and equity.

Based on the study findings, the following recommendations are proposed to enhance hybrid learning effectiveness through strategic digital leadership practices. Regarding technology integration, institutions should implement comprehensive infrastructure development plans that address the 10% connectivity gap identified in the data, with particular attention to private institutions where 14.4% of students lack internet access. Administrators should establish technology resource centers, develop offline-compatible learning materials, and create institutional partnerships with internet service providers to ensure equitable access. Faculty development programs should focus on building competencies in selecting and implementing appropriate educational technologies that can function effectively across varying connectivity conditions, thereby strengthening the positive relationship (β = 0.198, p = 0.001) between technology integration and learning outcomes.

For communication and collaboration enhancement, educational institutions should establish multi-channel communication systems tailored to their specific demographic profiles, particularly considering the distinct age distributions between private and public institutions. These systems should facilitate meaningful student-faculty interactions and peer collaboration through both synchronous and asynchronous modalities, accommodating diverse schedules and connectivity limitations. Regular assessment of communication effectiveness through student feedback mechanisms will help refine approaches, reinforcing the significant positive relationship (β = 0.216, p = 0.001) between communication practices and learning outcomes in hybrid environment.

Finally, given that policy development and implementation emerged as the strongest predictor of learning outcomes ($\beta = 0.327$, $p < 0.001$), institutions should prioritize establishing comprehensive policy frameworks specifically addressing hybrid learning implementation. These policies should clearly articulate technology requirements, communication expectations, assessment strategies, and provisions for students with connectivity challenges. Policies should be developed through inclusive consultation processes, effectively communicated across all institutional levels, and regularly evaluated for effectiveness. Professional development for administrators and faculty should emphasize policy interpretation and implementation skills, focusing on translating institutional guidelines into effective classroom practices that enhance learning outcomes while ensuring equitable educational experiences across diverse student populations.

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