Effectiveness of Virtual Learning Methods on Students' ICT Academic Performance: Evidence from Junior Secondary Schools in Lagos State Education District III

[1]Okediji, A.A., [1]Uzosike, A.O., [1]Obaseki, V.O. [2]Ogundaini, R.S. (Ph. D.) and [2]Ogbole B.

[1]Department of Integrated Science Education, Federal College of Education (Technical), Akoka

[2]Department of Chemistry Education, Federal College of Education (Technical), Akoka

adejareokediji@gmail.com

Abstract

This study examined the effectiveness of virtual learning methods on the academic performance of Junior Secondary School (JSS) students in Information and Communication Technology (ICT) within Education District III, Lagos State. Using a descriptive survey design, data were collected from 100 JSS students using a validated 4-point Likert-scale questionnaire. Results revealed that virtual learning positively influenced students' understanding and mastery of ICT concepts (mean scores: 2.7–3.3), with students reporting improved comprehension, increased confidence in practical tasks, and adequate preparation for real-world applications. While challenges such as limited hands-on coding practice (mean = 2.7) and mild isolation (mean = 2.5) were noted, overall acceptance was high. Students indicated stable infrastructure support, including reliable electricity and internet access (mean = 3.1), suitable curriculum design, and strong institutional backing from school management (mean = 3.3) and government authorities (mean = 3.4). The study concludes that virtual learning is a viable instructional approach for ICT education at the JSS level when supported by adequate infrastructure, teacher capacity, and policy frameworks. Recommendations include enhancing interactive simulation-based tools, strengthening teacher training in virtual pedagogy, and promoting equitable access to digital resources.

Keywords: Virtual learning, ICT education, academic performance, junior secondary school, digital literacy, Lagos State

Introduction

The integration of Information and Communication Technology (ICT) into education has fundamentally transformed pedagogical practices globally, shifting from teacher-centered instruction to more interactive, student-centered learning environments. Virtual learning, broadly

defined as instruction delivered through digital platforms and online resources, has emerged as a critical alternative and complement to traditional face-to-face methods. This transformation became particularly pronounced during the COVID-19 pandemic, which forced educational institutions worldwide to rapidly adopt remote learning modalities (Olanrewaju et al., 2021; Azubuike et al., 2020).

Globally, the COVID-19 pandemic affected approximately 1.6 billion learners across 190 countries, with 94% of the world's student population impacted by school closures (Azubuike et al., 2020). In Nigeria specifically, school closures disrupted learning for over 39 million primary and secondary school students, highlighting both the urgent need for digital learning infrastructure and the stark inequalities in access to technology (Olanrewaju et al., 2021). While developed nations quickly transitioned to remote and digital learning options with considerable success, many developing countries, including Nigeria, faced significant challenges related to infrastructure deficits, socioeconomic disparities, and teacher preparedness (Adeleke, 2021).

Research evidence suggests that ICT integration can yield substantial benefits for student learning when implemented effectively. Meta-analytic studies indicate that technology use in education produces small to moderate positive effects on academic achievement, particularly when digital tools are aligned with pedagogical goals and include adaptive feedback mechanisms (Bebell & O'Dwyer, 2010). Students taught using ICT-based instruction have been shown to score higher on achievement tests compared to those receiving conventional instruction (Okoro & Ekpo, 2016; Agrahari & Singh, 2013). Furthermore, ICT-enabled classrooms demonstrate enhanced student engagement, with learners scoring 7-8 points higher in exams and exhibiting increased attendance rates (92% vs. 85%) compared to traditional settings (Strelan et al., 2020).

However, the effectiveness of virtual learning is not universal and depends critically on several contextual factors. Teacher readiness, institutional support, pedagogical approaches, and students' access to technology significantly mediate learning outcomes (Martin et al., 2020; Scherer et al., 2021). Research indicates that only 8.5% of instructors possess high readiness for online teaching, while 39.4% exhibit low readiness, suggesting substantial variability in educators' preparedness

for digital instruction (Scherer et al., 2021). Pedagogical and online communication readiness have been identified as the most significant predictors of teaching effectiveness and student satisfaction in virtual environments (Downing & Dyment, 2013).

At the junior secondary school (JSS) level in Nigeria, ICT serves as a foundational subject designed to equip learners with digital literacy, computational thinking, and practical competencies essential for participation in the digital economy. The National Policy on Education emphasizes ICT integration as a mechanism for achieving national development goals and preparing students for 21st-century challenges (Federal Republic of Nigeria, 2024). However, the effectiveness of virtual learning methods in improving academic performance in ICT remains uncertain, particularly in contexts characterized by persistent infrastructural disparities and digital divides.

Education District III in Lagos State, comprising Eti-Osa, Epe, and Ibeju-Lekki local government areas, represents a diverse socio-economic landscape with significant variation in access to technology, internet connectivity, and teacher preparedness (Falobi, 2014). The district encompasses both urban and semi-urban communities, creating a complex educational environment where some schools possess relatively robust digital infrastructure while others face challenges, including inconsistent electricity supply, limited ICT facilities, and inadequate teacher training in online pedagogy. Research on digital gaps in Nigerian secondary schools has revealed that approximately 70% of students lack access to essential digital devices necessary for effective online learning, and significant disparities exist between students in government (public) schools and their private school counterparts (Olanrewaju et al., 2021).

The digital divide in Nigeria extends beyond mere device ownership to encompass internet connectivity speed, electricity availability, technological knowledge, and parental support capacity; all of which directly influence students' ability to engage meaningfully with virtual learning platforms (Adeleke, 2021). Socioeconomic status, parental education level, school type (public vs. private), and geographic location (urban vs. rural) have all been identified as significant determinants of students' access to and success in remote learning environments (Azubuike et al.,

2020). These multifaceted challenges raise critical questions about whether virtual learning methods can effectively serve all students or whether they risk exacerbating existing educational inequalities.

While international evidence suggests that virtual learning can enhance student engagement and accessibility when properly implemented (Ziden et al., 2021; Carrillo et al., 2020), localized empirical studies examining its impact on ICT performance among Nigerian JSS students remain limited. Most existing Nigerian research has focused on tertiary education contexts or has documented challenges without systematically assessing learning outcomes (Olanrewaju et al., 2021). This study addresses this gap by investigating how virtual learning methods influence students' understanding, practical skills, and academic achievement in ICT within the specific context of Education District III, Lagos State.

Despite significant governmental and private sector investments in ICT infrastructure and the widespread adoption of virtual learning platforms in Lagos State, academic performance in ICT among junior secondary students remains inconsistent and below expected standards. Following the COVID-19 pandemic, schools in Education District III implemented various virtual learning modalities—including synchronous live classes, asynchronous learning management systems, and hybrid approaches—with the expectation that these digital platforms would enhance teaching effectiveness, improve accessibility, and raise students' academic achievement.

However, preliminary observations and anecdotal evidence from schools in Education District III reveal mixed outcomes. While some students demonstrate improved understanding of ICT concepts through virtual platforms and report increased confidence in digital tool usage, others struggle significantly with practical skill acquisition, experience difficulty maintaining concentration during online lessons, and face challenges adapting to technology-driven learning environments. These disparities appear closely linked to socioeconomic factors, with the digital divide creating differential access to functional devices, reliable internet connectivity, adequate physical learning spaces, and parental support (Azubuike et al., 2020).

Furthermore, many ICT teachers in District III face their own challenges in effectively delivering virtual instruction. Research indicates that teacher readiness for online teaching is multifaceted, encompassing technological competence, pedagogical adaptability, online communication skills, and time management capabilities (Martin et al., 2020; Scherer et al., 2021). Limited professional development opportunities in online pedagogy, inadequate institutional support for digital content creation, and difficulties in assessing students' practical competencies in virtual settings all contribute to reduced teaching effectiveness. These teacher-level challenges compound student-level barriers, creating a complex implementation problem.

This study, therefore, addresses the central problem of whether virtual learning methods contribute to measurable improvements in JSS students' conceptual understanding, practical skills, and overall ICT achievement in Education District III, or whether implementation challenges and access barriers prevent these platforms from realising their potential. Without such empirical evidence, policymakers and educators lack the basis needed for informed decisions on digital learning investments and instructional strategies.

Research Questions

1. To what extent does virtual learning influence Junior Secondary school students' understanding and mastery of ICT concepts?
2. What is the impact of virtual learning on students' academic performance in ICT compared to traditional face-to-face instruction?
3. What challenges do Junior Secondary school students and teachers face in adopting and implanting virtual learning methods for ICT education, and what support systems exist to address them?

Methodology

This study employed a descriptive survey research design to systematically collect and analyze data on students' perceptions and experiences with virtual learning in ICT education. The descriptive survey approach was selected because it enables researchers to describe existing conditions, opinions, and behaviors within a specific population without manipulating variables, making it well-suited for investigating students' self-reported experiences with virtual learning platforms and their perceived effects on learning outcomes. The population for this study comprised all JSS students enrolled in ICT courses within public junior secondary schools in Education District III, Lagos State. Using stratified random sampling technique, a total of 100 students were selected from JSS 2 and JSS 3 classes across multiple schools. The stratification ensured balanced representation across class levels, with students randomly selected from each stratum to minimize selection bias. A self-developed structured questionnaire titled 'Virtual Learning Effectiveness in ICT Education Scale' was used to collect data. The instrument consisted of 15 items organized into three sections corresponding to the study's research objectives: (a) influence of virtual learning on understanding and mastery of ICT concepts (5 items), (b) impact on academic performance compared to traditional learning (5 items), and (c) implementation challenges and support systems (5 items). All items were measured using a 4-point modified Likert scale (Strongly Agree = 4, Agree = 3, Disagree = 2, Strongly Disagree = 1). Content and face validity were established through expert review by three educational technology specialists with expertise in ICT curriculum, online pedagogy, and educational assessment. The experts independently reviewed the instrument for clarity, relevance, and alignment with research objectives, suggesting minor revisions to item wording that were incorporated into the final version. Reliability was assessed using Cronbach's alpha coefficient, which measures internal consistency by examining the correlation among items within each scale dimension. A pilot test involving 30 students not included in the main study yielded a Cronbach's alpha of 0.82, indicating acceptable internal consistency according to conventional standards ($\alpha \geq 0.70$). Questionnaires were administered to respondents during regular school hours with assistance from ICT teachers who explained the study's purpose and assured students of confidentiality. Respondents completed

the questionnaires independently, and all instruments were retrieved on the same day to ensure a high response rate and data completeness. The 100% response rate achieved reflects the controlled administration environment and students' willingness to participate. Data were analyzed using descriptive statistics including frequencies, percentages, and arithmetic means. For each questionnaire item, weighted mean scores were calculated using the formula: $\bar{x} = \Sigma fx/N$, where $\bar{x}$ represents the mean score, F represents frequency of responses at each scale point, X represents the scale value, and N represents the total number of responses. A decision rule of mean ≥ 2.5 was applied to determine item acceptance, with this threshold representing the midpoint of the 4-point scale. Items with mean scores of 2.5 or above were interpreted as indicating positive perceptions or agreement with the statement, while scores below 2.5 indicated negative perceptions or disagreement.

Results

Demographic Characteristics

Table 1 presents the demographic distribution of the 100 respondents who participated in the study. The sample consisted of 52 males (52%) and 48 females (48%), indicating a relatively balanced gender representation. In terms of class level distribution, 52 students (52%) were enrolled in JSS 3, while 48 students (48%) were in JSS 2. This near-equal distribution across both gender and class level enhances the representativeness of the sample and supports the generalizability of findings across the junior secondary ICT student population in Education District III. **Table 1:** Demographic Characteristics of Respondents (N = 100)

Variable (Gender)	Frequency	Percentage (%)
Male	52	52.0
Female	48	48.0
(Class Level)		
JSS 2	48	48.0
JSS 3	52	52.0
Total	100	100.0

Influence of Virtual Learning on Understanding of ICT Concepts

Table 2 presents students' perceptions regarding how virtual learning methods influenced their understanding and mastery of ICT concepts. All five items in this dimension received mean scores ranging from 2.7 to 3.3, surpassing the acceptance threshold of 2.5 and indicating overall positive perceptions of virtual learning's impact on conceptual understanding.

Table 2: Students' Perceptions on Virtual Learning's Influence on ICT Concept Mastery

Item	Mean	Decision
Virtual learning improved understanding of core ICT concepts	3.3	Accepted
Confident in applying ICT concepts in practical assignments	3.3	Accepted
Virtual learning improved ability to practice coding/software use	2.7	Accepted
Collaborative virtual activities enhanced understanding	3.1	Accepted
Virtual learning prepares adequately for real-world ICT tasks	3.2	Accepted

Students reported strong agreement that virtual learning improved their understanding of core ICT concepts (M = 3.3) and increased their confidence in applying ICT knowledge to practical assignments and projects (M = 3.3). These high mean scores suggest that virtual learning platforms effectively supported conceptual learning and knowledge application. Students also perceived that virtual learning adequately prepared them for real-world ICT tasks and industry expectations (M = 3.2), indicating that digital instructional methods aligned well with practical competency development. Additionally, collaborative virtual activities such as group discussions and peer interactions were viewed as enhancing understanding (M = 3.1).

However, the lowest mean score in this dimension was observed for students' ability to practice coding or use ICT software effectively through virtual platforms (M = 2.7). While this score still

met the acceptance threshold, indicating overall agreement, its relative position suggests that hands-on technical skill development represents a weaker aspect of virtual ICT instruction compared to conceptual learning.

Impact of Virtual Learning on Academic Performance

Table 3 presents students' perceptions comparing virtual learning to traditional face-to-face instruction across dimensions related to academic performance, resource availability, and learning experience quality. All five items yielded mean scores at or above the 2.5 acceptance threshold, ranging from 2.5 to 3.3.

Table 3: Impact of Virtual Learning on Academic Performance

Item	Mean	Decision
Experienced isolation during virtual learning	2.5	Accepted
Sufficient opportunities for practical application	3.3	Accepted
Stable and affordable internet connectivity	3.1	Accepted
Instructor feedback quality equal to face-to-face	3.3	Accepted
Virtual learning increased workload	3.3	Accepted

Students perceived that instructors provided feedback in virtual settings with quality equivalent to that in face-to-face classes (M = 3.3). Students also reported that virtual learning provided sufficient opportunities for practical application of knowledge (M = 3.3). Infrastructure adequacy received moderate-to-strong endorsement, with students reporting relatively stable and affordable internet connectivity (M = 3.1). Students acknowledged that virtual learning increased their workload compared to traditional face-to-face instruction (M = 3.3). The item on feelings of isolation during virtual learning received the lowest mean score (M = 2.5), exactly at the acceptance threshold.

Implementation Challenges and Support Systems

Table 4 presents students' perceptions regarding institutional support, infrastructure availability, and systemic factors enabling virtual ICT learning. All five items in this dimension received mean scores between 3.1 and 3.4, indicating strong perceived support from multiple stakeholders and adequate enabling conditions.

Table 4: Institutional Support and Infrastructure for Virtual Learning

Item	Mean	Decision
Virtual learning develops future-relevant ICT skills	3.3	Accepted
ICT curriculum suitable for virtual delivery	3.1	Accepted
Government provides adequate support	3.4	Accepted
Electricity supply stable enough for virtual learning	3.1	Accepted
School management supports virtual ICT learning	3.3	Accepted

Students perceived strong support from government or education authorities for virtual ICT learning (M = 3.4), the highest mean score across all 15 items in the study. This suggests that students recognize and appreciate policy-level commitments to digital learning, possibly reflecting awareness of Lagos State's ICT education initiatives. School management support was also rated highly (M = 3.3), indicating effective institutional leadership in creating enabling environments for virtual instruction. Students further agreed that virtual learning develops future-relevant ICT skills (M = 3.3), reflecting confidence that digital learning experiences prepare them for employment and further education in technology fields.

Curriculum suitability for virtual delivery received moderate endorsement (M = 3.1). Electricity supply stability was similarly rated at M = 3.1.

Discussion

The findings from this study provide empirical evidence that virtual learning methods are generally effective in enhancing ICT education among junior secondary students in Education District III, Lagos State. The consistently positive mean scores across all measured dimensions—ranging from 2.7 to 3.4 on a 4-point scale—indicate broad student acceptance of virtual learning and perceived benefits for their ICT competency development. These results align with international metaanalytic evidence suggesting that ICT integration can produce positive effects on academic achievement when digital tools are pedagogically aligned and include appropriate feedback mechanisms (Bebell & O'Dwyer, 2010; Okoro & Ekpo, 2016).

Students' strong agreement that virtual learning improved their understanding of core ICT concepts (M = 3.3) and increased their confidence in practical applications (M = 3.3) suggests that digital platforms effectively supported constructivist learning processes. According to constructivist theory, meaningful learning occurs when students actively construct knowledge through interaction with content, peers, and instructors rather than passively receiving information (Jonassen, 1999). Virtual learning environments, when properly designed, facilitate this active knowledge construction through interactive multimedia, collaborative tools, and opportunities for self-paced exploration. The high ratings for collaborative virtual activities (M = 3.1) further support this interpretation, indicating that peer interaction and social learning remained viable in online settings.

However, the relatively lower mean score for coding practice (M = 2.7)—though still above the acceptance threshold—highlights a persistent challenge in virtual ICT instruction. Practical programming skills require iterative hands-on experimentation, immediate debugging feedback, and often benefit from instructor presence during problem-solving processes (Downing & Dyment, 2013). While virtual platforms can incorporate code editors, simulators, and automated testing tools, they may not fully replicate the affordances of physical computer laboratories where instructors can observe students' work directly and provide real-time assistance. This finding suggests that hybrid instructional models combining virtual content delivery with periodic in-

person practical sessions may optimize learning outcomes, particularly for skill-intensive ICT competencies.

The students' perception that instructor feedback quality in virtual settings equals that in face-to-face classes (M = 3.3) is particularly encouraging and contradicts common assumptions about diminished instructor-student interaction in online environments. This finding may reflect teachers' successful adaptation to digital communication tools and their strategic use of discussion forums, email, and video conferencing to maintain feedback quality. Research on online teaching effectiveness emphasizes that pedagogical readiness—including ability to design engaging activities, facilitate discussions, and provide timely personalized feedback—is a stronger predictor of student satisfaction than technological competence alone (Martin et al., 2020; Downing & Dyment, 2013). The positive feedback perceptions suggest that ICT teachers in Education District III may possess adequate pedagogical readiness for online instruction.

The reported increase in workload associated with virtual learning (M = 3.3) warrants careful consideration by educational administrators and policymakers. While increased cognitive engagement and time-on-task can benefit learning, excessive workload may lead to burnout, reduced motivation, and inequitable outcomes for students balancing schoolwork with household responsibilities or part-time employment. Research on online learning indicates that effective time management and self-regulation are critical student competencies that require explicit instruction and support (Scherer et al., 2021). Teachers and curriculum designers should work to balance rigorous learning expectations with realistic time demands, incorporating scaffolding and organizational tools to help students manage their learning efficiently.

The mild feelings of isolation reported by students (M = 2.5) align with documented social-emotional challenges of virtual learning. The COVID-19 pandemic highlighted how school closures and extended online learning can reduce peer interaction, diminish sense of community, and contribute to loneliness—factors that negatively affect both learning motivation and mental health (Adnan, 2020; Hazwani et al., 2020). While the mean score exactly at the acceptance threshold suggests isolation was not a severe problem, it remains an area requiring pedagogical

attention. Strategies to enhance social presence in virtual ICT classes might include regular small-group breakout sessions, peer programming activities, collaborative projects with clear role assignments, and intentional community-building activities at the beginning of courses.

Perhaps the most striking finding is the high level of perceived institutional support across multiple dimensions. Students reported strong support from government authorities (M = 3.4), school management (M = 3.3), and adequate infrastructure including electricity (M = 3.1) and internet connectivity (M = 3.1). These perceptions contrast sharply with research documenting severe digital gaps in many Nigerian educational contexts. National studies have found that approximately 70% of Nigerian students lack essential digital devices, with particularly acute disparities in rural areas and among students from low socioeconomic backgrounds (Olanrewaju et al., 2021; Azubuike et al., 2020). The positive infrastructure perceptions in Education District III may reflect several factors: (a) the district's relatively urban character with better infrastructure compared to rural areas, (b) targeted investments by Lagos State government in ICT education infrastructure, (c) students' comparison of their circumstances to less-privileged peers elsewhere, or (d) sample selection effects if participating schools represent better-resourced institutions within the district.

The finding that students perceive the ICT curriculum as suitable for virtual delivery (M = 3.1) is pedagogically significant. Curriculum appropriateness for online instruction depends on factors including content modularity, availability of digital resources, feasibility of virtual assessment, and alignment between learning objectives and digital pedagogical affordances (Gay, 2016). The moderate-to-strong endorsement suggests that the JSS ICT curriculum possesses these characteristics, though targeted revisions incorporating more interactive simulations, virtual labs, and multimedia resources could further enhance its effectiveness in online environments.

It is important to acknowledge several limitations that qualify these findings. First, the study relied exclusively on students' self-reported perceptions rather than objective learning outcome measures such as examination scores or practical skills assessments. While perceptions provide valuable

insights into learning experiences, they may not perfectly correspond to actual achievement gains. Future research should incorporate both perceptual and performance measures to provide a more comprehensive evaluation. Second, the sample of 100 students, while adequate for descriptive purposes, limits statistical power for detecting small effects and restricts generalizability. Third, the study did not include a comparison group receiving traditional face-to-face instruction, preventing causal claims about virtual learning's effects relative to conventional approaches. Finally, the cross-sectional design captures perceptions at a single point in time and cannot illuminate how experiences and effectiveness may evolve as students and teachers gain experience with virtual platforms.

Conclusion

This study provides empirical evidence that virtual learning is an effective instructional approach for ICT education at the junior secondary level in Lagos State Education District III. Students' perceptions across all measured dimensions consistently exceeded acceptance thresholds, indicating that virtual platforms successfully supported conceptual understanding, practical skill development, and overall ICT competency acquisition. The high mean scores for improved understanding of core ICT concepts, increased confidence in practical applications, and adequate preparation for real-world ICT tasks collectively suggest that virtual learning environments, when properly implemented, can facilitate meaningful learning experiences comparable to traditional face-to-face instruction.

However, the findings also reveal specific challenges that require targeted interventions. The lower rating for coding practice indicates that hands-on technical skill development remains more difficult to achieve through virtual platforms compared to conceptual learning. This suggests that optimal ICT instruction at the JSS level may require hybrid approaches that combine virtual content delivery with periodic in-person practical sessions, particularly for programming and software use activities. Additionally, the reported increase in workload and mild feelings of social isolation suggest that virtual learning implementation must attend carefully to students' time management needs and social-emotional wellbeing.

The strong perceived support from government authorities, school management, and adequate infrastructure availability represent critical enabling conditions for virtual learning effectiveness. These findings suggest that targeted investments in digital infrastructure, teacher capacity building, and institutional support systems can create environments where virtual learning thrives. The study demonstrates that in contexts with adequate enabling conditions—reliable electricity and internet, supportive institutional policies, teacher pedagogical readiness, and appropriately designed curriculum—virtual learning can serve as a viable and effective modality for ICT education.

Importantly, these findings should not be interpreted as indicating that virtual learning is universally effective across all Nigerian educational contexts. The relatively positive outcomes observed in Education District III likely reflect specific contextual advantages including urban location, government investment prioritization, and institutional capacity that may not be present in rural districts or less-resourced states. The persistent digital divide documented in Nigerian education research (Olanrewaju et al., 2021; Azubuike et al., 2020) means that virtual learning effectiveness will vary substantially across contexts based on infrastructure availability, socioeconomic factors, and institutional support levels.

Looking forward, the successful implementation of virtual learning in Education District III provides a model that other districts and states can adapt to their specific contexts. Sustained effectiveness will require ongoing investment in digital infrastructure, continuous professional development for teachers in online pedagogy, regular curriculum updates to incorporate emerging technologies, and attention to equity issues to ensure that virtual learning benefits all students rather than exacerbating existing inequalities. With these commitments, virtual learning holds significant promise for advancing ICT education and preparing Nigerian students for participation in an increasingly digital global economy.

Recommendations

Based on the findings of this study, the following recommendations are proposed to enhance the effectiveness and equity of virtual ICT learning in Education District III and potentially other Nigerian educational contexts:

1. Educational authorities should invest in developing virtual ICT laboratories equipped with coding environments, simulation software, and interactive programming platforms to strengthen hands-on skill development. Cloud-based development environments such as Replit, Code.org, or Microsoft MakeCode could provide accessible alternatives to physical computer labs.

2. Teacher professional development programs should emphasize effective virtual pedagogy beyond basic technology skills. Training should address online communication strategies, formative assessment techniques in digital environments, strategies for maintaining student engagement, methods for creating inclusive online communities, and approaches for balancing workload expectations with student wellbeing.

3. Schools should implement hybrid learning models that strategically combine virtual content delivery with periodic in-person practical sessions. For instance, theoretical concepts, demonstrations, and collaborative discussions could occur virtually while hands-on coding practice, troubleshooting sessions, and practical assessments occur in physical labs on a rotating or condensed schedule.

4. Government and school administrators should sustain and expand investments in reliable electricity infrastructure and affordable internet connectivity. Where reliable grid electricity remains challenging, schools might explore solar power installations or backup generators specifically for ICT learning spaces. Partnerships with telecommunications companies could potentially provide subsidized data packages for students.

5. Curriculum designers should revise the JSS ICT curriculum to explicitly incorporate digital learning best practices, including modular content organization, multimedia resources, interactive

elements, and assessment approaches suited to online environments. The curriculum should also include digital citizenship, online safety, and ethical technology use as core components.

6. Schools should establish structured support systems to address social-emotional dimensions of virtual learning. This might include regular check-ins on student wellbeing, virtual office hours for informal interaction, peer mentoring programs, and explicit instruction in time management and self-regulation strategies for online learning.

7. Policymakers should commission longitudinal research tracking virtual learning effectiveness over time and across diverse contexts. Studies should incorporate objective learning outcome measures alongside perceptual data and should investigate factors that mediate effectiveness to guide evidence-based policy development.

8. Equity considerations must remain central to virtual learning implementation. Schools should conduct regular technology access audits, provide device lending programs for students lacking personal computers, offer after-school access to school ICT facilities, and ensure that virtual learning does not inadvertently privilege students from higher socioeconomic backgrounds.

References

Adeleke, R. (2021). Digital divide in Nigeria: The role of regional differentials. African Journal of Science, Technology, Innovation and Development, 13(3), 333–346. https://doi.org/10.1080/20421338.2020.1748335

Adnan, M. (2020). Online learning amid the COVID-19 pandemic: Students' perspectives. Journal of Pedagogical Sociology and Psychology, 2(1), 45–51. https://doi.org/10.33902/JPSP.2020261309

Agrahari, A., & Singh, S. (2013). The impact of information and communication technology (ICT) on achievement of students in chemistry at secondary level of CBSE and UP Board in India. International Journal of Science and Research, 2(8), 126–129.

Azubuike, O. B., Adegboye, O., & Quadri, H. (2020). Who gets to learn in a pandemic? Exploring the digital divide in remote learning during the COVID-19 pandemic in Nigeria. International Journal of Educational Research Open, 2(2), 100022. https://doi.org/10.1016/j.ijedro.2020.100022

Bebell, D., & O'Dwyer, L. M. (2010). Educational outcomes and research from 1:1 computing settings. Journal of Technology, Learning, and Assessment, 9(1), 1–15.

Carrillo, P., Onofa, M., & Ponce, J. (2020). Information technology and student achievement: Evidence from a randomized experiment in Ecuador. IDB Working Paper, 223. https://doi.org/10.18235/0002266

Downing, J. J., & Dyment, J. E. (2013). Teacher educators' readiness, preparation, and perceptions of preparing preservice teachers in a fully online environment: An exploratory study. The Teacher Educator, 48(2), 96–109. https://doi.org/10.1080/08878730.2012.760023

Falobi, O. V. (2014). An investigation into the impact of ICT on commercial students' academic performance in public schools in Lagos State. Journal of Association of Business Educators of Nigeria, 1(1), 48–154.

Federal Republic of Nigeria. (2024). National Policy on Education (7th ed.). NERDC Press.

Gay, G. H. (2016). An assessment of online instructor e-learning readiness before, during, and after course delivery. Journal of Computing in Higher Education, 28(2), 199–220. https://doi.org/10.1007/s12528-016-9115-z

Hazwani, H., Rosli, M. S., & Norazah, M. N. (2020). Exploring students' readiness and perception towards utilizing e-learning in educational settings. International Journal of Psychosocial Rehabilitation, 24(5), 3741–3752.

Jonassen, D. H. (1999). Designing constructivist learning environments. In C. M. Reigeluth (Ed.), Instructional design theories and models: A new paradigm of instructional theory (Vol. 2, pp. 215–239). Lawrence Erlbaum Associates.

Martin, F., Stamper, B., & Flowers, C. (2020). Examining student perception of readiness for online learning: Importance and confidence. Online Learning, 24(2), 38–58. https://doi.org/10.24059/olj.v24i2.2053

Okoro, C. O., & Ekpo, E. E. (2016). Effects of information and communication technology (ICT) application on academic performance of business education students in skills-based courses. International Journal of Research and Education, 3(1), 66–74.

Olanrewaju, G. S., Adebayo, S. B., Omotosho, A. Y., Nwagbara, U., & Nwagbara, N. I. (2021). Left behind? The effects of digital gaps on e-learning in rural secondary schools and remote communities across Nigeria during the COVID-19 pandemic. International Journal of Educational Research Open, 2(2), 100092. https://doi.org/10.1016/j.ijedro.2021.100092

Scherer, R., Howard, S. K., Tondeur, J., & Siddiq, F. (2021). Profiling teachers' readiness for online teaching and learning in higher education: Who's ready? Computers in Human Behavior, 118, 106675. https://doi.org/10.1016/j.chb.2020.106675

Strelan, P., Osborn, A., & Palmer, E. (2020). The flipped classroom: A meta-analysis of effects on student performance across disciplines and education levels. Educational Research Review, 30, 100314. https://doi.org/10.1016/j.edurev.2020.100314

Ziden, A. A., Ismail, I., Spian, R., & Kumutha, K. (2021). The effects of ICT use in teaching and learning on students' achievement in science subjects in a primary school in Malaysia. Malaysian Journal of Distance Education, 13(2), 19–32.