

Information Communication Technologies Use as Predictor of Research Enhancement and Productivity Among Doctoral Students in Faculty of Education, University of Nigeria, Nsukka

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Abstract—This research investigated the role of Information Communication Technologies (ICT) in predicting research production enhancement and productivity of doctoral students in the Faculty of Education, University of Nigeria, Nsukka (UNN). The rapid growth of ICT tools such as statistical packages, reference managers, cloud-based collaboration environments, databases, and artificial intelligence tools in research has significantly transformed the epistemic environment of doctoral research worldwide. Despite the institutional embrace of ICT in federal universities in Nigeria, there is limited empirical research with systematic and methodological rigour on the ICT-research productivity relationship among doctoral students. The research design was a correlational survey. The study population was all 312 doctoral students in all the departments in the Faculty of Education, UNN, registered for the 2022/2023 academic session. The Taro Yamane (1967) formula at 5% margin of error was used to determine a sample of 175. Stratified random proportionate sampling was adopted in the eight departments. The response was 168 (96.0%) usable questionnaires. A structured validated questionnaire, "ICT Use and Research Productivity Questionnaire" (ICTURPQ) with a Cronbach's $\alpha = 0.91$ was used. Mean, standard deviation (SD), Pearson Product-Moment Correlation (PPMC), and multiple linear regression ($\alpha = 0.05$) were used for data analysis. The study found a high degree of ICT use by doctoral students (overall mean = 3.88, SD = 0.69). Research productivity and enhancement were high (overall mean = 3.61 SD = 0.74). There was a strong positive correlation between ICT use and research productivity ($r = .784$, $n = 168$, $p < .001$). Multivariate linear regression analysis also established that both the factors of ICT use ($F(5, 162) = 61.43$, $p < .001$; $R^2 = .655$) and ICT use individually significantly predicted research productivity. The research identifies that ICT use is a powerful predictor of doctoral research productivity, a multi-dimensional construct and recommends holistic capacity-building in ICT, enhanced institutional support and digital research skills training for doctoral students at UNN.

Keywords—Information communication technologies; ICT; research productivity; doctoral students; TPACK; UTAUT2; University of Nigeria Nsukka; statistical software; reference management; digital databases.

I. INTRODUCTION

The impact of Information Communication Technologies (ICT) on academic research productivity is a key empirical question in 21st-century higher education research. Doctoral education, as the culminating level of the formal academic training system, is especially important in this relationship: the doctoral degree is defined everywhere as a research degree, and the quality, efficiency and novelty of doctoral research are the ultimate measures of the effectiveness of doctoral programmes. In the Nigerian higher education system, and particularly at the University of Nigeria, Nsukka (UNN), one of Nigeria's most prestigious federal research universities, doctoral education in the Faculty of Education is uniquely significant, given the fact it is a critical source of researchers, policy analysts, curriculum developers and educational administrators who will govern Nigerian education for years to come (Obi & Nwosu, 2022; Eze, Onyishi & Okonkwo, 2021). Despite these implications, questions about the degree to which doctoral students in this faculty are using ICT to increase their research productivity remain unanswered.

In this study, "Information Communication Technologies (ICT)" refers to the complex interaction of digital hardware, software, communication, and network technologies that

support the creation, capture, processing, storage, retrieval, exchange and distribution of information and knowledge in research and academia (Mwalongo, 2021; UNESCO, 2020). Specifically in doctoral research, this includes a diverse array of ICT tools and applications: statistical data analysis software (SPSS, R, NVivo, ATLAS.ti, STATA); reference and citation management software (Mendeley, Zotero, EndNote); online communication and collaboration platforms (Google Drive, Microsoft Teams, ResearchGate, Academia.edu); digital library databases (JSTOR, Scopus, Web of Science, Google Scholar); qualitative data collection tools and increasingly, artificial intelligence research tools like big language models, AI-based literature review, and automated transcription and coding software (Omoike, 2022; Dukić & Dukić, 2022; Eze et al., 2021) (Survey Monkey, KoBo Toolbox, Google Forms). The rich tapestry of this ICT ecosystem implies that ICT use in doctoral research cannot be reduced to a single variable but is a multi-dimensional construct that encompasses technical skills, level of usage, purposeful application and contextualisation in the research process.

The dependent variable in this study, research enhancement (qualitative) and productivity (quantitative), is defined as the qualitative and quantitative outcomes of doctoral research work, including completed doctoral dissertations, peer-reviewed publications. Research enhancement, the qualitative

dimension, involves the development of research skills, research design, analysis and scholarly writing skills that flow from the process of conducting research work. Research productivity and enhancement, therefore, represent the outputs and capacity-building results of doctoral research work, which are increasingly digital in the modern world. The theoretical connection between ICT use and these research outcomes is the primary empirical focus of the current research.

The history of ICT use in academic research can be mapped from the early use of personal computers and word processors in the 1980s, the proliferation of the internet in the 1990s, the advent of electronic databases and digital libraries in the early 2000s, and the present age of cloud computing, big data analytics, open science platforms, and AI-based research tools (Baro et al., 2020; Rowlands et al., 2019). The stages of this trajectory have successively extended the reach, capability and channels of communication of academic researchers, accelerating the pace of research, democratising access to knowledge across the world, (UNESCO, 2020; Mwalongo, 2021). In Nigeria, this history has been mixed: initial ICT use in Nigerian universities was hampered by infrastructural weaknesses, expensive equipment, slow bandwidth and a deficit of technical skills. University of Nigeria, Nsukka, as one of the pioneering institutions of higher learning in Nigeria, has been at the vanguard of this ICT adoption wave, with investments in digital library resources, campus Wi-Fi access, computer laboratories and online research platforms. However, there remains a question mark over whether the institutional provision of ICT promotes effective, productive ICT use by its doctoral researchers.

We draw on two theoretical models to underpin this research. In the context of doctoral research, TPACK would expect that doctoral students who not only have technical ICT skills but also discipline-specific knowledge of how specific ICTs interact with their research methodology and content knowledge will be more productive in their research than those who only have generic technological skills. The prediction from this theory has implications for the design of ICT training for doctoral students, which should not be generic digital literacy training but instead discipline- and methodology-specific ICT integration training. The Unified Theory of Acceptance and Use of Technology 2 (UTAUT2) proposed by Venkatesh, Thong, and Xu (2012) and extended by Venkatesh, Thong, and Xu (2019) to include hedonic motivation, habit and experience as factors influencing technology use, offers a complementary lens to TPACK for understanding the behavioural drivers of ICT use by doctoral students. UTAUT2 proposes performance expectancy, effort expectancy, social influence, facilitating conditions, hedonic motivation, habit and experience as the key predictors of ICT use behaviour, suggesting that ICT use will be greatest when users perceive ICT as a tool that helps them achieve their performance goals, when institutional factors support ICT use, and when ICT use becomes habituated with repeated experience.

A critical review of the current evidence on ICT and research productivity in Nigerian universities has shown both increasing evidence in support of the claim that ICT is positively associated with research productivity, and several

key methodological and analytical shortcomings that this study seeks to overcome. Most studies in Nigeria have concerned general ICT use among undergraduates or all academic staff, not specifically doctoral students, whose ICT needs, skills and research productivity landscape are distinct from those of undergraduates or teaching-oriented academics (Eze et al., 2021; Omoike, 2022). Postgraduate students are in a unique position in the institution: they are both advanced students and researchers, often conducting original empirical research over a period of three to five years which culminates in a thesis that makes an original contribution to the field of study. Moreover, the studies conducted in Nigeria so far have been descriptive in nature, describing awareness or access to ICTs without inferentially testing the specific predictive relationships between ICT use and particular research productivity indicators. This study seeks to redress these shortcomings by taking a multi-dimensional, theoretically-informed and inferentially rigorous approach to studying ICT use as a predictor of doctoral research productivity in the Faculty of Education, UNN.

Existing empirical research on ICT use and research productivity in university settings in Africa and elsewhere consistently supports a positive association. Eze et al. (2021) reported that doctoral students in Nigerian federal universities who reported high ICT integration in their research exhibited significantly higher (an average of 2.3 per academic year) levels of publications (peer reviewed) than those with low ICT integration (0.6). Omoike (2022) found that use of statistical software and reference management tools were the strongest ICT predictors of the quality of doctoral dissertations among students in south-eastern Nigeria, explaining 44.1% and 38.6% of variance in supervisor ratings of dissertation quality respectively. Dukić and Dukić (2022) reported that in Croatia, ICT competence was significantly and positively related with the research productivity of doctoral students ($r = .69, p < .01$), with use of cloud collaboration tools and bibliometric databases the most significant predictors. Mwalongo (2021) also reported a significant association between intensity of ICT use and research productivity in Tanzanian universities ($r = .71, p < .001$), which was explained by the ability of ICT to speed up literature search, data processing and preparation of manuscripts for publication. Baro et al. (2020) reported that Nigerian academics using Scopus and Web of Science for literature review cited and were cited by significantly more highly-cited publications than those who only used Google Scholar, highlighting the importance of the nature of ICT use on research productivity. Aina et al. (2021) critically proposed that using reference management software alone could improve the accuracy of doctoral students' citations by more than 60%, freeing up time and allowing students to focus more on the essence of their work. International studies include Mikki et al. (2020) who concluded that in Norway, the use of open science platforms was a significant predictor of research impact. Odeh, Rababah and Al-Zboon (2022) found that the use of artificial intelligence-powered literature review tools by Jordanian doctoral students was associated with a 47% decrease in the time spent on literature review, which has productivity implications.

At the University of Nigeria, Nsukka to be precise, the Faculty of Education offers eight departments including educational foundations, curriculum studies, educational administration, vocational education and special education, each with a PhD programme whose graduates' research projects employ quantitative and qualitative approaches to various educational topics. The faculty has enjoyed the benefits of UNN's investment in digital library subscriptions, campus fibre-optic network and research computer facilities. But based on anecdotal evidence and existing literature, the use of these resources by doctoral students is not uniform across departments, with variations in supervision and the technological ability and skills of students (Obi & Nwosu, 2022). There is no published empirical study that has specifically examined the relationship between ICT use and research productivity of doctoral students in UNN's Faculty of Education, hence the institutional knowledge gap that this study seeks to address.

A. Objectives of the Study

The following specific objectives guided the study:

1. To determine the level of ICT use for research purposes among doctoral students in the Faculty of Education, University of Nigeria, Nsukka.
2. To assess the level of research enhancement and productivity among doctoral students in the Faculty of Education, University of Nigeria, Nsukka.
3. To establish the relationship between ICT use and research enhancement and productivity among doctoral students in the Faculty of Education, University of Nigeria, Nsukka.
4. To determine the extent to which dimensions of ICT use (statistical software use, reference management, database/digital library access, cloud collaboration, and AI-assisted tools) individually and collectively predict research enhancement and productivity among doctoral students in the Faculty of Education, University of Nigeria, Nsukka.

B. Research Hypotheses

The following null hypotheses were tested at a 0.05 level of significance:

- H₀₁: There is no significant relationship between ICT use and research enhancement and productivity among doctoral students in the Faculty of Education, UNN, at $\alpha = 0.05$.
- H₀₂: Dimensions of ICT use do not significantly predict research enhancement and productivity among doctoral students in the Faculty of Education, UNN, at $\alpha = 0.05$.

II. METHODOLOGY

This research used a correlational survey design, suitable for addressing the strength, direction and predictive nature of the relationship between ICT use (independent variable) and Improvement in research productivity and enhancement (dependent variable) without the experimental manipulation of the researcher. Correlational designs further allow the application of multiple regression analysis and Pearson product-moment correlation to evaluate unique predictive effects of numerous ICT factors to research productivity and simultaneously test for bivariate relationships.

The research was carried out in the Faculty of Education of University of Nigeria, Nsukka (UNN), Enugu State, Nigeria. UNN is a leading federal research university in Nigeria founded in 1960 and the Faculty of Education is one of the oldest and most productive education research faculties in sub-Saharan Africa. The faculty has eight departments: Educational Foundations, Curriculum Studies, Educational Administration and Planning, Science Education, Arts Education, Vocational Technical Education, Physical and Health Education and Special Education and Rehabilitation. All the departments offer doctoral (Ph.D.) degrees.

The population for this study were all 312 registered and active doctoral (Ph.D.) students in the Faculty of Education, UNN, in the 2022/2023 academic session as per the Faculty Postgraduate Coordinator's figures. Only doctoral (Ph.D.) students were included; master's degree students and other researchers were excluded. Applying the Taro Yamane (1967) formula at $e = 0.05$: $n = 312 / [1 + 312(0.0025)] = 312 / 1.78 \approx 175$. The eight departments were proportionately stratified for random sampling. Systematic random sampling (every second student on the postgraduate register) was then applied within each strata (department) to select individuals. A total sample of 175 PhD students was targeted.

The data collection instrument was a researcher-constructed questionnaire called the "ICT Use and Research Productivity Questionnaire" (ICTURPQ). The questionnaire was organised into five sections: Section A (biographical information, 7 items); Section B (ICT use for research - 20 items and 5 ICT dimensions: statistical software, reference management, digital databases, cloud collaboration and AI-assisted tools - 4 items per dimension); Section C (research enhancement and productivity outcomes - 15 items); and Section D (institutional ICT challenges - 10 items). The 5-point Likert scale Very High Extent (5), High Extent (4), Moderate Extent (3), Low Extent (2) and Not at All (1) was used in Sections B, C and D. Five experts (three in Educational Technology and Library and Information Science and two in Research Methodology and Measurement) at the University of Nigeria, Nsukka reviewed the ICTURPQ for content validity. Seven items were modified as a result of their suggestions. The questionnaire was pre-tested on 30 PhD students in the Faculty of Education, University of Lagos and found to have a Cronbach's alpha of 0.91, indicating excellent reliability (Nunnally & Bernstein, 1994). A total of 168 (96.0%) of the 175 questionnaires distributed were returned and found complete. Descriptive statistics (mean and standard deviation) were used to analyse data for Objectives 1 and 2 (a criterion mean of 3.00 was used for decision making); Pearson Product-Moment Correlation for Objective 3 and H₀₁; and multiple linear regression (Enter method) for Objective 4 and H₀₂, with SPSS version 26. Effect size conventions, as adopted by Cohen (1988), were used to interpret correlation and regression coefficients.

III. RESULTS

Results are presented in accordance with the four research objectives and two null hypotheses. All analyses are based on 168 usable responses.

A. Level of ICT Use for Research (Objective 1)

Table II presents mean scores for the 20 ICT use items, organised across five research-relevant ICT dimensions.

The overall ICT use mean was 3.76 (SD = 0.82), indicating a high overall level of ICT engagement. Dimension 3 (Digital Database/Library Access) was the highest-rated dimension (mean = 4.02), followed by Dimension 4 (Cloud Collaboration, mean = 3.89) and Dimension 2 (Reference Management, mean = 3.70). Dimension 5 (AI-Assisted Tools) was the lowest-rated dimension (mean = 3.52) but remained above criterion. Automated transcription tool use (Item 18, mean = 2.94) was the only individual item rated below the criterion mean.

B. Research Enhancement and Productivity Level (Objective 2)

Table III presents mean scores for the 15 research productivity and enhancement items.

The overall research productivity mean was 3.61 (SD = 0.85), indicating a moderately high level. The highest-rated items were improvement in literature review breadth through digital databases (Item 31, mean = 3.97), improved citation accuracy via reference management (Item 28, mean = 3.94), and overall research productivity enhancement (Item 35, mean = 3.88). Research grant application or receipt (Item 26, mean = 2.88) was the only item rated below the criterion mean, indicating a critical productivity gap in research funding engagement.

TABLE I. Demographic Profile of Respondents (n = 168)

Variable / Category	Frequency (n)	Percentage (%)
Gender		
Male	89	53.0
Female	79	47.0
Total	168	100.0
Department		
Educational Foundations	22	13.1
Curriculum Studies	24	14.3
Educational Administration & Planning	22	13.1
Science Education	23	13.7
Arts Education	19	11.3
Vocational Technical Education	18	10.7
Physical & Health Education	20	11.9
Special Education & Rehabilitation	20	11.9
Total	168	100.0
Stage of Doctoral Study		
Year 1 (Coursework)	44	26.2
Year 2 (Proposal/Field Work)	61	36.3
Year 3–5 (Writing/Completion)	63	37.5
Total	168	100.0
Personal Device Ownership		
Laptop + Smartphone	138	82.1
Smartphone only	24	14.3
No personal device	6	3.6
Total	168	100.0
ICT Training Received		
Formal institutional ICT training	71	42.3
Self-taught / informal training	82	48.8
No training at all	15	8.9
Total	168	100.0

TABLE II. Level of ICT Use for Research among Doctoral Students (n = 168)

S/N	Item: ICT Use for Research (by Dimension)	N	Mean	SD	Remark
	Dimension 1: Statistical Analysis Software Use				
1	I use SPSS for quantitative data analysis in my doctoral research.	168	4.12	0.71	High
2	I use qualitative analysis software (NVivo / ATLAS.ti) for qualitative data.	168	3.44	0.91	Moderate
3	I use R or STATA for advanced statistical modelling and analysis.	168	3.18	1.02	Moderate
4	Statistical software use has improved the rigour of my research analysis.	168	3.94	0.74	High
	Dimension 1 Mean	168	3.67	0.85	High
	Dimension 2: Reference Management Software Use				
5	I use Mendeley to organise and manage my research references.	168	3.82	0.79	High
6	I use Zotero or EndNote for citation and bibliography generation.	168	3.41	0.94	Moderate
7	Reference management software has reduced errors in my citations.	168	4.01	0.71	High
8	I use reference management tools to share literature with supervisors and peers.	168	3.54	0.88	High
	Dimension 2 Mean	168	3.70	0.83	High
	Dimension 3: Digital Database and Library Access				
9	I regularly access Scopus and Web of Science for literature review.	168	3.88	0.78	High
10	I use Google Scholar daily for identifying relevant academic literature.	168	4.41	0.58	Very High
11	I access JSTOR, ProQuest, and ERIC for discipline-specific resources.	168	3.62	0.87	High
12	Digital database access has significantly broadened my literature base.	168	4.18	0.67	High
	Dimension 3 Mean	168	4.02	0.73	High
	Dimension 4: Cloud Collaboration and Communication Tools				
13	I use Google Drive / Docs for collaborative research writing and storage.	168	3.91	0.75	High
14	I communicate with supervisors and co-authors via email and Microsoft Teams.	168	4.08	0.69	High
15	I use ResearchGate and Academia.edu to share and access research papers.	168	3.72	0.82	High
16	Cloud tools have improved my collaboration with supervisors and peers.	168	3.84	0.78	High
	Dimension 4 Mean	168	3.89	0.76	High
	Dimension 5: AI-Assisted and Advanced Digital Research Tools				
17	I use AI-powered tools (e.g., ChatGPT, Elicit) to support literature reviews.	168	3.28	1.04	Moderate
18	I use automated transcription tools for qualitative interview data.	168	2.94	1.11	Low
19	I use plagiarism detection software (Turnitin / iThenticate) for my manuscripts.	168	3.81	0.80	High
20	I use digital survey platforms (Google Forms/KoBoToolbox) for data collection.	168	4.04	0.72	High
	Dimension 5 Mean	168	3.52	0.92	Moderate-High
	Overall ICT Use Mean	168	3.76	0.82	High

C. Relationship between ICT Use and Research Productivity (Objective 3 / H₀₁)

Table IV presents the Pearson Product-Moment Correlation results.

TABLE III. Research Enhancement and Productivity among Doctoral Students (n = 168)

S/N	Item: Research Enhancement and Productivity Outcomes	N	Mean	SD	Remark
21	I have produced at least one peer-reviewed journal publication from my doctoral work.	168	3.48	0.92	Moderate
22	I have presented papers at local or international academic conferences.	168	3.62	0.87	High
23	My doctoral thesis/dissertation is progressing according to its approved timeline.	168	3.44	0.94	Moderate
24	ICT use has improved the quality of my literature review significantly.	168	3.91	0.75	High
25	My methodological rigour has improved through the use of statistical software.	168	3.72	0.82	High
26	I have applied for or received research funding/grants during my doctoral study.	168	2.88	1.08	Low
27	ICT tools have significantly shortened my data analysis turnaround time.	168	3.81	0.79	High
28	My use of reference management tools has improved my citation accuracy.	168	3.94	0.74	High
29	I have collaborated with other researchers through digital platforms.	168	3.58	0.88	High
30	ICT use has enhanced the overall quality of my doctoral research outputs.	168	3.87	0.77	High
31	My use of digital databases has expanded the scope of my literature review.	168	3.97	0.73	High
32	I am able to write and revise manuscripts more efficiently using ICT tools.	168	3.74	0.81	High
33	I have deposited research outputs in an institutional or open-access repository.	168	3.12	1.01	Moderate
34	ICT use has improved my ability to identify and fill research gaps.	168	3.68	0.84	High
35	Overall, ICT use has significantly enhanced my research productivity at UNN.	168	3.88	0.77	High
	Overall Research Productivity Mean	168	3.61	0.85	High

TABLE IV. Pearson Correlation, ICT Use and Research Enhancement and Productivity (n = 168)

Variables	N	r	r ²	p-value	Decision on H ₀₁
ICT Use (Overall Score) ↑	168				
Research Enhancement & Productivity	168	.784	.615	< .001	H ₀₁ Rejected

Note: $r = .784$; $r^2 = .615$; $p < .001$; two-tailed; $df = 166$

A significant positive and large correlation was established between overall ICT use and research productivity: $r(166) = .784$, $p < .001$. The coefficient of determination (R-squared = .615) indicates ICT use accounts for 61.5% of the shared variance in research productivity. As the computed r value

(.784) substantially exceeds the critical value at $df = 166$ and $\alpha = 0.05$, the null hypothesis H-01 is rejected. ICT use is significantly and positively related to research productivity among doctoral students in the Faculty of Education, UNN.

D. ICT Dimensions as Predictors of Research Productivity (Objective 4 / H₀₂)

Table V presents the multiple linear regression results with all five ICT dimensions entered simultaneously as predictors of research productivity.

TABLE V. Multiple Linear Regression, ICT Dimensions Predicting Research Productivity (n = 168)

ICT Dimension Predictor	B	Std. Error	β	t	p-value	Sig.
(Constant)	0.61	0.18		3.39	< .001	
Statistical Software Use	0.28	0.06	.301	4.67	< .001	✓
Reference Management Use	0.24	0.07	.267	3.43	< .001	✓
Digital Database/Library Access	0.31	0.07	.332	4.43	< .001	✓
Cloud Collaboration Tools	0.19	0.07	.211	2.71	.007	✓
AI-Assisted Research Tools	0.14	0.06	.158	2.33	.021	✓
Model: $R = .809$ $R^2 = .655$ $Adj. R^2 = .645$ $F(5, 162) = 61.43$, $p < .001$						
Decision on H₀₂: Rejected, All five ICT dimensions significantly predict research productivity						

The overall regression model was statistically significant: $F(5, 162) = 61.43$, $p < .001$, $R^2 = .655$, adjusted $R^2 = .645$. All five ICT dimensions independently and significantly predicted research productivity (all p-values < .05). Digital database and library access was the strongest predictor ($\beta = .332$), followed by statistical software use ($\beta = .301$), reference management ($\beta = .267$), cloud collaboration ($\beta = .211$), and AI-assisted tools ($\beta = .158$). H₀₂ is rejected. The regression equation is: Research Productivity = $0.61 + 0.28(\text{Statistical Software}) + 0.24(\text{Reference Management}) + 0.31(\text{Database Access}) + 0.19(\text{Cloud Collaboration}) + 0.14(\text{AI Tools})$.

E. Institutional ICT Challenges Facing Doctoral Researchers

Table VI presents doctoral students' perceptions of institutional ICT challenges.

All ten challenge items exceeded the criterion mean, with an overall challenge mean of 3.87 (SD = 0.77). Unreliable internet connectivity (mean = 4.32), power instability (mean = 4.24), and high data subscription costs (mean = 4.19) emerged as the most critical structural barriers to ICT use for doctoral research.

IV. DISCUSSION

The descriptive results for Research Objective 1 showed a high level of ICT use by doctoral students in UNN's Faculty of Education (overall mean = 3.76, SD = 0.82). This trend is in line with the use of ICTs among Nigerian doctoral researchers documented in the recent literature, although it is significantly higher than documented in previous studies. Eze et al. (2021) also found high ICT usage among doctoral students in a few universities in south-eastern Nigeria, citing the rise in the

prevalence of smart phones and better internet connectivity on university campuses.

TABLE VI. Institutional ICT Challenges among Doctoral Students (n = 168)

S/N	Item: Institutional ICT Challenges	N	Mean	SD	Remark
36	Unreliable internet connectivity on campus hampers my ICT use for research.	168	4.32	0.62	Very High
37	High cost of data subscription limits my sustained use of digital databases.	168	4.19	0.66	High
38	Inadequate access to statistical software licences is a significant challenge.	168	3.94	0.74	High
39	Insufficient institutional ICT training for doctoral students is a barrier.	168	3.88	0.77	High
40	Power supply instability disrupts my use of ICT tools for research.	168	4.24	0.64	High
41	Limited access to premium databases (Scopus/Web of Science) is a challenge.	168	3.81	0.80	High
42	Insufficient supervisor guidance on ICT tools for research is a challenge.	168	3.52	0.88	High
43	Technical difficulties with institutional ICT systems reduce my productivity.	168	3.71	0.83	High
44	Lack of ICT support staff or help desk for doctoral researchers is a barrier.	168	3.64	0.85	High
45	Concerns about data privacy and research security limit my cloud tool use.	168	3.42	0.91	Moderate
	Overall Challenge Mean	168	3.87	0.77	High

The prominence of the use of Google Scholar (mean = 4.41) and access to digital databases as the highest-rated ICT use dimension (Dimension 3 mean = 4.02) is especially noteworthy, as it supports Baro et al. (2020), who confirmed Google Scholar's status as the primary research tool for Nigerian doctoral researchers. But the sub-criterion rating for use of automated transcription tools (mean = 2.94) and the mean rating for AI-assisted tool use (mean = 3.28) indicates that use of emerging ICT tools is not widespread, a finding that is corroborated by Dukić and Dukić (2022) who reported a considerable lag in the adoption of AI research tools even in technologically advanced doctoral research communities in Europe, citing concerns about accuracy, ethics and training.

The fact that 48.8% of doctoral students were self-taught in their use of ICTs, with only 42.3% having received formal ICT training at the institution, is a particularly significant finding that helps explain the data on ICT use. Self-taught ICT skills, while reflecting student agency, are typically shallow, personalised, focused on the use of common ICT skills (Google Scholar, Microsoft Word), rather than using more sophisticated but less intuitive ICT tools (NVivo, Stata, Mendeley) (Mwalongo, 2021; Omoike, 2022). This is in line with the finding that use of qualitative data analysis software (mean = 3.44) and advanced statistical modelling (mean = 3.18) rated much lower than more popular ICTs, implying that self-taught ICT skills are not sufficient to meet the demands of doctoral

research. This finding is consistent with Okike (2020) who studied Nigerian doctoral researchers and suggested that the failure of universities to establish structured ICT training at the doctoral level is an institutional failure that limits the productivity potential of even highly motivated doctoral students. The research productivity results (overall mean = 3.61, SD = 0.85) suggest a moderately high level of research productivity among the sample, with ICT-related skills (use of digital databases to improve literature review, mean = 3.97; use of reference managers to improve citation accuracy, mean = 3.94) rated higher than productivity measures based on research output (grant application/receipt, mean = 2.88; deposit of research into open-access repository, mean = 3.12). This finding is consistent with a broader trend in the Nigerian and African literature on ICTs and research productivity: ICTs have a major positive impact on the quality of research processes, but a more limited positive impact on quantitative research output metrics, including publications, citations, grants, due to structural factors including lack of access to predatory-free publication outlets, lack of research funding, lack of institutional incentives for doctoral students to publish (Aina et al., 2021; Obi & Nwosu, 2022). The particularly low rate of grant application (mean = 2.88) is of concern and reflects the findings of Obi and Nwosu (2022) who noted that lack of awareness of research funding opportunities and grant writing skills is a key factor affecting doctoral research in education faculties in Nigeria.

The Pearson correlation result, $r = .784$ ($p < .001$, $R^2 = .615$) reflects a strong and significant positive association between ICT use and research productivity, the highest value reported in the Nigerian literature. This finding strongly supports the theoretical predictions of both the TPACK (Mishra & Koehler, 2006; Mouza et al., 2020) and UTAUT2 (Venkatesh et al., 2019) theories regarding the productivity-enhancing benefits of incorporating ICTs into doctoral research operations, while clearly disproving H01. The Pearson r value of .784 is somewhat higher than the .712 value reported by Mwalongo (2021) for Tanzanian doctoral researchers and the .69 value reported by Dukić and Dukić (2022) for Croatians, but certainly in line with the large-effect-size correlations reported in this literature. This finding supports the inference that the ICT - research productivity association is a generalised empirical phenomenon, rather than an isolated national or institutional-specific event. Cohen's (1988) categorisation of r values greater than .50 as large effect sizes confirms the relationship is both statistically significant and of practical importance: differences in ICT use account for 61.5% of variance in research productivity scores, an extremely important finding for doctoral program administrators and library and information science staff at UNN.

The multiple regression (Table V) results are the most policy-relevant of this study, breaking down the overall ICT-Research productivity relationship into the unique contributions of the five ICT dimensions. Each of the five dimensions are significant predictors, individually and collectively accounting for 65.5% of the variance in research productivity ($R^2 = .655$, $F(5, 162) = 61.43$, $p < .001$), with adjusted $R^2 = .645$ showing a small degree of model overfitting. Digital database and library

access was the strongest predictor ($\beta = .332, t = 4.43, p < .001$), followed by statistical software use ($\beta = .301, t = 4.67, p < .001$) and reference management ($\beta = .267, t = 3.43, p < .001$). These results are in line with Omoike (2022), who also found statistical software and reference management as the strongest ICT predictors of dissertation quality in south-eastern Nigerian universities. The impact of even the least-used ICT dimension (AI-assisted research tools, Dimension 5 mean = 3.52) as a predictor ($\beta = .158, t = 2.33, p = .021$) has a predictive implication: given that AI research tools are increasingly being adopted, their impact on research productivity is likely to grow significantly in future. This predictive result echoes Odeh et al. (2022) who foretold that within five years, AI research tool adoption would be the most important ICT predictor of research productivity in developing country universities.

The challenge data (Table VI) offer an important contextual perspective on the strengths and weaknesses of the ICT-productivity relationship described above. The most pressing issues with the infrastructure are the erratic internet (mean = 4.32) and electricity supplies (mean = 4.24). These findings are in line with virtually all major ICT studies conducted in Nigeria over the last ten years, and they also emphasize the disparity between theory and practice in the ICT infrastructure of Nigerian federal universities (Obi & Nwosu, 2022; Okike, 2020). The second most critical challenge identified was the high costs of data subscriptions (mean = 4.19), which is significant for doctoral research, given the need for high volume database access over time, which cannot be supported by the low data packages affordable to most Nigerian doctoral students on government stipends. The lack of access to high-end databases (mean = 3.81) is linked to this finding: although UNN subscribes to databases through the National Universities Commission (NUC) Tertiary Education Trust Fund (TET Fund) Research Grant schemes and the Nigerian Research and Education Network (NgREN), their usage by doctoral students is inadequate. Ocholla and Ocholla (2021) noted similar deficits between institutional database subscriptions and doctoral student utilisation in South African universities, due to lack of promotion of subscriptions by library staff and lack of induction support for new doctoral students.

V. CONCLUSION AND RECOMMENDATIONS

This research has yielded strong, multi-dimensional empirical evidence that ICT use is a reliable, highly statistically significant and also practically meaningful predictor of research enhancement and productivity among doctoral students of University of Nigeria, Nsukka. The overall correlation $r = .784$ and the multiple regression model which accounts for 65.5% of the variance in research productivity together demonstrate ICT use, and specifically access to digital databases, use of statistical software and reference management, as key predictors of quality and productivity of doctoral research at UNN.

The study recommends the following evidence-based interventions: (i) the Faculty of Education, UNN, should introduce a compulsory, credit-bearing "Doctoral Research Computing and ICT Skills" module in the first year of every Ph.D. program, addressing statistical software, reference

management, database search, and data management skills; (ii) the UNN library and ICT directorate should organise targeted awareness and training sessions on institutional database subscriptions (Scopus, Web of Science, JSTOR) for doctoral students; (iii) UNN should prioritise the purchase of multi-user licences for NVivo, STATA and Mendeley Premium, with dedicated access for doctoral students; (iv) the National Universities Commission should extend the TET Fund database subscription program to ensure institution-wide broadband-suitable subscriptions to premium research databases for all registered doctoral students; (v) doctoral supervisors should include explicit ICT skills development in doctoral supervision agreements; and (vi) longitudinal studies should be carried out to examine the long-term impact of structured ICT training on doctoral completion and post-doctoral research publication.

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