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UTAUT in Architectural Education: Empirical Validation in the Nigerian Context

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Abstract

Information and communication technologies have profoundly transformed architectural practice, yet empirical investigation of how architecture students in sub-Saharan Africa accept and engage with Computer-Aided Architectural Design (CAAD) tools remains sparse. This study deploys the Unified Theory of Acceptance and Use of Technology (UTAUT) as the primary theoretical framework to investigate CAAD acceptance and use among architecture students in southwest Nigeria. A cross-sectional survey of 735 students drawn from six universities, spanning federal, state, and private proprietorship, was analysed using descriptive statistics, chi-square cross-tabulations, and categorical regression. The acceptance model explained 54.2% of variance in CAAD acceptance ($R^2 = 0.542$, $F = 31.937$, $p = .000$), with awareness of CAAD use emerging as the sole statistically significant acceptance predictor ($\beta = 0.674$, $p = .044$). The use model identified ten significant predictors of CAAD use ($R^2 = 0.387$, $F = 10.860$, $p = .000$), including prior CAAD experience, curriculum integration, studio capacity, length of study, educational attainment, e-studio availability, awareness, gender, age, and large-format printer availability. These findings validate UTAUT's core constructs, performance expectancy, social influence, and facilitating conditions in an architectural education context in a developing economy, while revealing that awareness, operationalised here as Rogers' (1995) observability, exerts a uniquely dominant predictive role not typically foregrounded in UTAUT applications. Implications for curriculum reform, infrastructure investment, and national ICT policy are discussed.

1. Introduction

Digital technologies have fundamentally altered every dimension of architectural practice, from design conception through construction documentation to client communication, and the consensus among scholars is that architectural education must respond with commensurate urgency (Kolarevic, 2003; Mohd-Nor et al., 2009; Sa'ad, 2001). According to Sa'ad (2001), electronic technology has moved architecture from the drawing board to cyberspace, with profound implications for the architect and the practice of architecture, and Novak (1997, as cited in Sa'ad, 2001) argued that the most advanced and dramatic solutions to architectural problems in the twenty-first century could not have been conceived without the computer. Adegbinle (2012) identified digital design technology as one of the most essential tools in contemporary architectural education, and McDonald (1997, as cited in Sa'ad, 2001) observed that design technology has democratised architectural decision-making by facilitating client participation in the design process.

Yet, despite the manifest importance of Computer-Aided Architectural Design (CAAD) to professional practice, empirical evidence indicates that its adoption in Nigerian architectural education has been critically uneven and inadequate. Olotuah (2004) found that fewer than 30% of Nigerian architects received CAAD training during their undergraduate studies, and Olotuah et al. (2012) concluded that the absence of, or inadequate, CAAD training in schools of architecture in Nigeria has significantly affected architects' performance in practice. The consequence is that graduates of Nigerian universities lack the prerequisite digital skills to compete effectively in the global job market (Uwakonye, 2018). This skills

deficit persists notwithstanding the Nigerian National Information and Communication Technology Policy (Federal Republic of Nigeria, 2012), which explicitly mandates the integration of ICT into the national education curriculum and the introduction of mandatory ICT courses at all tiers of education.

Despite the existence of this policy framework and a small but growing body of local studies (Dare-Abel, 2013; Kaduma, 2013; Ogunsote & Prucnal-Ogunsote, 2004; Ogunsote et al., 2006), the literature on the factors that determine CAAD acceptance and use in Nigerian architectural education remains sparse. Critically, no prior study had applied a unified, validated theoretical framework to model CAAD acceptance and use across multiple Nigerian universities simultaneously. This paper addresses that gap by deploying the Unified Theory of Acceptance and Use of Technology (UTAUT; Venkatesh et al., 2003), the most comprehensive technology acceptance framework available, to empirically investigate the determinants of CAAD acceptance and use among architecture students in southwest Nigeria.

UTAUT was selected for three reasons. First, it synthesises and extends eight prior technology acceptance models, including the Technology Acceptance Model (TAM; Davis, 1989), the Theory of Planned Behaviour (TPB; Ajzen, 1991), the Theory of Reasoned Action (TRA; Ajzen & Fishbein, 1980), and Innovation Diffusion Theory (IDT; Rogers, 1995), offering greater explanatory coverage than any single predecessor model. Second, it was validated across multiple organisational contexts and accounted for 70% of the variance in technology use intention (Venkatesh et al., 2003), though its performance in academic and developing-country settings remains underexplored. Third, the longitudinal field study that produced UTAUT was conducted in an organisational workplace context, raising the important, as yet unanswered question of how UTAUT performs when applied to an academic learning environment in sub-Saharan Africa, where CAAD has been adopted as part of the educational curriculum (Uwakonye, 2018, p. 26).

The paper makes four primary contributions to the literature. First, it presents the first multi-university, UTAUT-grounded empirical study of CAAD acceptance and use in Nigerian architectural education. Second, it validates the UTAUT framework in a design education context within a developing economy. Third, it reveals the exceptional dominance of awareness, operationalised here as Rogers' (1995) observability, a CAAD acceptance predictor that diverges significantly from mainstream UTAUT findings that foreground performance expectancy and effort expectancy. Fourth, it generates empirical evidence to inform curriculum reform, infrastructure policy, and accreditation standards for Nigerian schools of architecture.

2. Literature Review

2.1 CAAD in Architectural Education

Computer-Aided Architectural Design encompasses the use of computer technology in the architectural design process and in architectural education (Uwakonye, 2018). Achten (1996) distinguished between computational issues, database structures, exchange formats, programming techniques, interface

design, and architectural issues, cost calculations, production drawings, simulation, design synthesis, and form generation as the two principal domains of CAAD application. Kalay (2004) noted that the duality of the history of computers in architecture, emphasising either the formal computer-science perspective or the architectural design perspective, has contributed to definitional ambiguity in the literature.

Achten (1996) further classified computer systems in architectural education into four types: social systems (general-purpose tools such as word processing); professional systems (off-the-shelf architectural software such as AutoCAD, Revit, and ArchiCAD); educational systems (modified professional tools tailored to specific pedagogical purposes); and innovative systems (research-generated software such as automated plan recognition and virtual reality design environments). The present study focuses on professional systems, as these are the tools directly relevant to architectural practice and the primary locus of CAAD adoption in Nigerian universities.

The global trajectory of CAAD adoption in education has been uneven. Koutamanis et al. (1993, as cited in Uwakonye, 2018) found that most universities in America, Europe, and Asia introduce CAAD in the first year of their architecture programmes, while Asperl (2005) documented that 85% of secondary school students in Austria study CAD. In contrast, Nigerian architectural schools have been characterised by late, inconsistent, and under-resourced integration of CAAD curricula (Ogunsote et al., 2006; Olotuah, 2004, 2005), a situation this study empirically documents and seeks to address.

2.2 Technology Acceptance Theoretical Models

A substantial body of theory has been developed to explain individual technology acceptance and use behaviour. Davis (1989) proposed the Technology Acceptance Model (TAM), positing that perceived usefulness and perceived ease of use are the primary determinants of behavioural intention to use a technology, with intention mediating actual system use. TAM has been extensively validated across diverse technological contexts (Davis et al., 1989; Szajna, 1996) and remains the dominant framework in technology acceptance research.

Ajzen and Fishbein's (1980) Theory of Reasoned Action (TRA) provides the foundational behavioural science underpinning of TAM, positing that attitude toward behaviour and subjective norm determine behavioural intention. Ajzen (1991) extended TRA into the Theory of Planned Behaviour (TPB) by adding perceived behavioural control as a third determinant of intention, addressing TRA's limitation of assuming that behaviour is always volitional. Thompson et al. (1991) adapted Triandis' (1977) theory into the Model of PC Utilisation (MPCU), emphasising job-fit, complexity, social factors, and facilitating conditions as predictors of PC use behaviour. Davis et al. (1992) and Venkatesh and Speier (1999) developed the Motivational Model (MM), distinguishing between extrinsic motivation (performance-related outcomes) and intrinsic motivation (enjoyment of the activity itself) as drivers of technology adoption. Rogers' (1995) Innovation Diffusion Theory (IDT) highlighted five innovation attributes, relative advantage, compatibility, complexity, trialability, and observability, as determinants of adoption rate and pattern.

Recognising the proliferation of competing models with overlapping constructs, Venkatesh et al. (2003) conducted a review and empirical comparison of eight major technology acceptance models and synthesised their key constructs into the Unified Theory of Acceptance and Use of Technology (UTAUT). UTAUT posits four core constructs as direct determinants of behavioural intention and use behaviour: (1) performance expectancy, the degree to which the individual believes that using the system will improve job performance; (2) effort expectancy, the degree of ease associated with system use; (3) social influence, the degree to which the individual perceives that important others believe he or she should use the system; and (4) facilitating conditions, the degree to which an organisational and technical infrastructure exists to support system use. UTAUT additionally identifies gender, age, experience, and voluntariness of use as moderators of these relationships. In its original validation, UTAUT explained 70% of the variance in use intention (Venkatesh et al., 2003), substantially outperforming any individual predecessor model.

As Shroff et al. (2011) observed, the theoretical models utilised to study user acceptance, adoption, and usage behaviour in educational technology research include TRA, TPB, TAM, and IDT, with TAM dominating the field. However, a persistent critique is that most TAM and UTAUT validation studies were conducted in Western, organisational, or general ICT contexts (Kripanont, 2006; Uwakonye, 2018), and the extent to which UTAUT's predictive structure holds in a professional design education context in a developing economy remains unestablished.

2.3 Conceptual Framework

The conceptual framework for the present study adapts UTAUT for the CAAD-in-education context (Uwakonye, 2018). The social influence construct was operationalised through the concept of psychological attachment (O'Reilly, 1986), drawing on Kelman's (1958) three processes of social influence, compliance, identification, and internalisation, to account for the complex social pressures students face regarding CAAD adoption in a structured educational setting. The facilitating conditions construct was operationalised as a composite resource base encompassing computing infrastructure, human capital, building infrastructure, and power supply, all of which are particularly salient determinants of technology use in the Nigerian university context. The model was further extended to include sustainability of use as a dependent on performance expectancy utilities derived from actual CAAD use, recognising that the adoption of professional software tools in education requires sustained engagement rather than merely initial acceptance.

3. Methodology

3.1 Research Design

A quantitative cross-sectional survey design was adopted, tailored to the UTAUT framework (Uwakonye, 2018, p. 31). The survey design was selected because it permits data collection across a large, geographically dispersed population; yields data amenable to inferential statistical analysis; allows

results to be generalised to the study population; and provides a temporally bounded snapshot of acceptance and use behaviour at a specific moment in the development of CAAD education in Nigeria.

3.2 Study Population and Sampling

The study population comprised architecture students from the 12 degree-awarding schools of architecture at universities in southwest Nigeria. Students at the 100 level were excluded because they are at the entry point of their study and lack the CAAD experience necessary to provide meaningful responses. The accessible population thus comprised 1,766 students at levels 200–600 (Uwakonye, 2018, p. 32).

A stratified random sampling procedure was employed. Universities were first stratified by proprietorship into three categories, federal, state, and private, and two universities were randomly selected from each category. The selected institutions were: University of Lagos (UNILAG; federal); Federal University of Technology Akure (FUTA; federal); Ladoke Akintola University of Technology, Ogbomosho (LAUTECH; state); Olabisi Onabanjo University, Ago-Iwoye (OOU; state); Covenant University, Ota (CU; private); and The Bells University of Technology, Ota (Bells; private). This stratification strategy ensured representation across the three classes of institutional ownership that characterise Nigerian higher education.

Sample size was determined using the Frankfort-Nachimias and Nachimias (1992) formula for populations under 10,000, yielding a calculated appropriate sample of 316 students, proportionately allocated across the six institutions. A total of 890 questionnaires were administered, and 735 valid responses were returned, representing a response rate of 61.25%, substantially above the 50% threshold commonly accepted as adequate for inferential analysis (Niles, 2006). Table 1 presents the institutional sample frame, calculated sample sizes, and actual respondent counts.

Table 1

Student Respondents by Institution and Proprietorship Type

Institution	Proprietorship	Pop. Frame	Calc. Sample	n Returned
University of Lagos (UNILAG)	Federal	312	56	162
Fed. Univ. of Technology, Akure (FUTA)	Federal	466	84	—
Ladoke Akintola Univ. of Tech. (LAUTECH)	State	277	50	153
Olabisi Onabanjo University (OOU)	State	259	47	—
Covenant University (CU)	Private	297	54	142
Bells University of Technology	Private	136	25	109
Total		**1,766**	**316**	**735**

Note.

Note. Population frame data from departmental records (2015). Dashes indicate institutions for which disaggregated return counts were not available in the original data; all responses were pooled into a total of n = 735. Source: Uwakonye (2018, p. 34, Table 3.2).

3.3 Instrumentation

Data were collected through a researcher-administered structured questionnaire comprising 60 variables operationally defined across five categories aligned with the four study objectives: (1) socio-economic characteristics (variables V1–V6: sex, age, marital status, educational attainment, degree programme, year of study); (2) extent of CAAD acceptance and use (V7–V41: awareness, curriculum integration, proficiency level, software platform usage by function); (3) resource base for CAAD adoption (V42–V50: studio availability and capacity, computing infrastructure, staffing, power supply, printing facilities); and (4) perceived benefits of CAAD (V51–V60: productivity, time savings, design coordination, representation, storage, retrieval, changeability, communication, and construction data generation) (Uwakonye, 2018, pp. 39–41, Table 3.3). In-depth interviews and on-site observations supplemented the questionnaire to provide contextual richness.

Software platforms investigated included AutoCAD, ArchiCAD, SketchUp, Autodesk Revit, and 3ds Max, covering the principal CAD software systems in use in Nigerian architectural practice. For each platform, students reported their usage across six functions: drafting, rendering, design generation, three-dimensional modelling, and animation.

3.4 Data Analysis

Quantitative data were analysed using the Statistical Package for the Social Sciences (SPSS) Version 21. Descriptive statistics, frequencies, percentages, and proportions characterised the study sample and the extent of CAAD acceptance and use. Chi-square (λ^2) cross-tabulations examined bivariate relationships between CAAD variables (awareness, curriculum integration, proficiency, platform use) and between CAAD use and socio-economic moderators (gender, age, marital status, educational attainment). Pearson product-moment correlations examined the relationships between CAAD use and continuous infrastructure variables (studio capacity, power supply hours, staff counts). Categorical regression analysis (CATREG), appropriate for ordinal and nominal dependent and independent variables, was employed to determine the factors significantly predicting CAAD acceptance (dependent variable: prior CAAD use) and CAAD use (dependent variable: proficiency level in CAAD use). Bootstrap estimation with 1,000 replications was used to compute standard errors for the regression coefficients, enhancing the robustness of inference.

4. Results

4.1 Socio-Economic Profile of Respondents

Of the 735 respondents, 538 (73.2%) were male, 190 (25.9%) were female, and 7 (0.95%) did not indicate gender. This gender distribution reflects the historically male-dominated nature of architectural education in Nigeria. The largest age cohort was 16–20 years (66.3%, n = 484), followed by the 21–25 years bracket (28.8%, n = 210), with 4.9% above 25 years. The majority (78.1%) were enrolled in the B.Sc. Architecture programme. These demographic characteristics are consistent with the profile of an undergraduate student population in a professional degree programme in a Nigerian university (Uwakonye, 2018, pp. 43–48, Tables 4.3–4.11).

4.2 Extent of CAAD Awareness, Curriculum Integration, and Proficiency

The vast majority of respondents (97.3%) reported awareness of CAAD use in architecture teaching and learning, while 78% reported that CAAD was formally taught as a course in their institution's curriculum. Among those who used CAAD, 26.8% self-assessed as beginner users, 54.3% as intermediate users, and 15.6% as advanced users, with only 3.3% reporting no use (Uwakonye, 2018, p. 50, Table 4.14). AutoCAD was the most widely used platform (approximately 91%), followed by SketchUp (approximately 57%), Revit (approximately 74%), with ArchiCAD and 3D Studio Max used by smaller subsets of respondents. The dominant functions across all platforms were drafting and three-dimensional modelling, with animation the least commonly practised function (Uwakonye, 2018, pp. 51–52, Table 4.17).

4.3 Resource Base for CAAD Adoption

Table 4.19 in the original thesis (Uwakonye, 2018, p. 54) documents substantial institutional variation in CAAD infrastructure. Power supply ranged from 24 hours per day (UNILAG, CU) to 12 hours (FUTA, Bells) and 7 hours (OOU), with LAUTECH reporting no dedicated CAAD studio. Studio opening hours ranged

from 9 hours per day at the best-resourced institutions to 7 hours at OOU. Pearson correlations confirmed strong positive relationships between CAAD proficiency and: power supply hours ($r = .888$, $p \leq .01$); studio opening hours ($r = .773$, $p \leq .01$); and large-format printer availability ($r = .802$, $p \leq .01$). These relationships indicate that facilitating conditions, operationalised as the physical resource base, are strongly associated with CAAD proficiency outcomes.

4.4 CAAD Acceptance: Chi-Square Findings

Chi-square analysis of the bivariate relationships between CAAD acceptance (prior use) and the variables hypothesised to influence it revealed consistent, significant associations. The relationship between acceptance and awareness of CAAD use was statistically significant ($\lambda^2 = 378$, $df = 4$, $p \leq .01$), with 85% of respondents who reported awareness actually using CAAD (Uwakonye, 2018, p. 101). The relationship between acceptance and CAAD curriculum integration was significant ($\lambda^2 = 35.8$, $df = 4$, $p \leq .01$), with 82% of respondents taught CAAD as a course using CAAD in teaching and learning (Uwakonye, 2018, p. 102). These results align with Rogers' (1995) IDT observability construct and Venkatesh et al.'s (2003) social influence construct, respectively.

Significant acceptance-software relationships were found for AutoCAD ($\lambda^2 = 57.8$, $p \leq .01$), AutoCAD for drafting ($\lambda^2 = 29.6$, $p \leq .01$), AutoCAD for rendering ($\lambda^2 = 14.8$, $p \leq .01$), AutoCAD for design generation ($\lambda^2 = 12.2$, $p \leq .02$), and AutoCAD for 3D modelling ($\lambda^2 = 6.54$, $p \leq .03$). Notably, AutoCAD for animation was not significant ($\lambda^2 = 12.2$, $p = .14$), consistent with Davis et al. (1989) and Szajna (1996), who demonstrated that ease of use becomes non-significant with increased experience, advanced functions like animation impose a higher experience threshold before adoption (Uwakonye, 2018, pp. 103–106). SketchUp and all its operational sub-functions were significantly associated with CAAD acceptance ($p \leq .01$ throughout) (Uwakonye, 2018, pp. 106–108).

4.5 Categorical Regression: Predictors of CAAD Acceptance

The categorical regression model for CAAD acceptance (dependent variable: prior use of CAAD; Table 4.25.2 in (Uwakonye, 2018, p. 109) identified one statistically significant predictor across all variables entered: awareness of CAAD use ($\beta = 0.674$, $p = .044$). The model summary indicates $R^2 = 0.542$, $F = 31.937$, $p = .000$, with an adjusted $R^2 = .525$ and an Apparent Prediction Error of .458 (Uwakonye, 2018, p. 130, Table 5.1). This means that awareness alone accounts for 54.2% of the variance in CAAD acceptance.

All other candidate variables, curriculum integration ($\beta = 0.108$, $p = .202$), educational attainment ($\beta = -0.023$, $p = .785$), year of study ($\beta = 0.048$, $p = .258$), degree programme ($\beta = 0.019$, $p = .773$), proficiency level ($\beta = -0.187$, $p = .092$), AutoCAD use ($\beta = 0.001$, $p = .994$), and all SketchUp function variables — were non-significant in the multivariate model (Table 4.25.2; Uwakonye, 2018, p. 109). Table 2 presents the categorical regression output for the acceptance model.

Table 2

Categorical Regression: Predictors of CAAD Acceptance (n = 735)

Predictor Variable	Beta (β)	Bootstrap SE	F	p
Awareness of CAAD use*	.674	.381	3.071	**.044**
CAAD as a curriculum course	.108	.085	1.604	.202
Highest educational attainment	−.023	.084	.074	.785
Year of study in school	.048	.043	1.284	.258
Degree programme	.019	.065	.083	.773
CAAD proficiency level	−.187	.120	2.397	.092
Use of AutoCAD	.001	.092	.000	.994
Use of AutoCAD for drafting	.013	.035	.142	.707
Use of AutoCAD for rendering	.054	.034	2.486	.115
Use of SketchUp	.010	.042	.054	.816
Use of SketchUp for drafting	.010	.026	.141	.707
Ease of storing design drawings	.051	.037	1.851	.174

Note. Dependent variable: Have you ever used CAAD in the teaching and learning of architecture? R^2 = .542, F = 31.937, p = .000. Bootstrap (1,000 replications). * Significant at p < .05. Source: Uwakonye (2018, p. 109, Table 4.25.2; p. 130, Table 5.1).

4.6 Categorical Regression: Predictors of CAAD Use

The categorical regression model for CAAD use (dependent variable: proficiency level in CAAD use; Table 4.27 in Uwakonye, 2018, p. 127) identified ten statistically significant predictors. The model summary indicates R^2 = 0.387, F = 10.860, p = .000, with adjusted R^2 = .352 and Apparent Prediction Error = .613 (Uwakonye, 2018, p. 131, Table 5.2). Table 3 presents the significant predictors, their standardised beta coefficients (bootstrap-estimated), and significance levels.

Table 3

Categorical Regression: Significant Predictors of CAAD Use (n = 735)

Significant Predictor	Beta (β)	Bootstrap SE	df	F	p
Prior use of CAAD (experience)	.265	.104	2	6.498	.002
CAAD in the curriculum	.249	.111	2	5.028	.007
Capacity of CAAD studio	.229	.081	1	8.035	.005
Year of study (length of stay)	.188	.047	3	16.172	.000
Highest educational attainment	.159	.056	4	8.163	.000
E-studio availability	.123	.059	1	4.410	.036
Awareness of CAAD use	.117	.057	2	4.262	.014
Gender (sex)	.085	.033	1	6.539	.011
Age	.073	.032	3	5.334	.001
Large-format printer availability†	−.316	.068	1	21.401	**.000**

Note. Dependent variable: Proficiency level in the use of CAAD. R^2 = .387, F = 10.860, p = .000. Bootstrap (1,000 replications). All ten predictors were statistically significant at p < .05. † Negative beta indicates inverse relationship (see Section 5.3 for discussion). Source: Uwakonye (2018, pp. 125–127, Table 4.27; p. 131, Table 5.2).

5. Discussion

5.1 The Dominance of Awareness: Diverging From UTAUT Predictions

The most striking finding of this study is the singular and overwhelming dominance of awareness as the sole statistically significant predictor of CAAD acceptance, accounting for 54.2% of acceptance variance. This diverges substantially from the UTAUT framework's prediction that performance expectancy, effort expectancy, and social influence jointly drive behavioural intention to accept technology (Venkatesh et al., 2003). In UTAUT's original validation, performance expectancy was identified as the strongest predictor of use intention (Venkatesh et al., 2003), yet in this study, performance expectancy variables (productivity, design coordination, ease of retrieval) did not achieve significance in the acceptance model.

This finding is better explained by Rogers' (1995) IDT, in which observability, the degree to which the results of an innovation are visible to others, is identified as a key determinant of adoption. Awareness of CAAD use directly corresponds to IDT's observability: students who can observe CAAD in teaching and peer practice are significantly more likely to adopt it themselves. This result aligns with Rogers (1995, as

cited in Mdnor et al., 2010), who suggested that observability is a predictor of technology acceptance, and is supported by Nambisan et al. (1999), Charbaji and Mikdashi (2003), Ilesanmi (2012), Rehman et al. (2012), Wan et al. (2012), and Oye et al. (2013), all of whom found awareness to be a moderator of behavioural intention to accept technology use (Uwakonye, 2018, p. 109).

The implication is significant: in contexts where CAAD adoption is at an early or uneven stage of diffusion, as in southwest Nigeria, the primary barrier to acceptance is not a negative evaluation of the technology's usefulness or ease of use, but simply a lack of exposure to it. This suggests that awareness campaigns, demonstration workshops, and peer-observation opportunities may be the most cost-effective interventions for improving CAAD acceptance, rather than pedagogical modifications or software simplification.

5.2 UTAUT Constructs in the CAAD Use Model

The ten-predictor use model maps coherently onto UTAUT's four core constructs and three moderators, providing substantial, if partial, validation of UTAUT in this design education context:

Performance expectancy is reflected in prior CAAD use (experience; β = 0.265) and curriculum integration (β = 0.249), both of which capture how exposure to and positive experience with CAAD in the structured educational setting reinforces continued and more advanced use. The finding that curriculum-mandated CAAD use drives proficiency aligns with Venkatesh et al.'s (2003) finding that social influence is particularly potent under mandatory conditions, a result also consistent with the observation that 82% of students taught CAAD as a course actually use it (Uwakonye, 2018, p. 118).

Facilitating conditions, operationalised as the composite resource base, are represented by studio capacity (β = 0.229), e-studio availability (β = 0.123), and, counter-intuitively, large-format printer availability (β = −0.316). The first two confirm Thompson et al.'s (1991) finding that objective environmental factors enabling technology use are significant predictors of that use, and Venkatesh et al.'s (2003) conclusion that facilitating conditions have a direct effect on use beyond that explained by behavioural intentions alone. Bergeron et al. (1990) further argued that these influences increase with experience as users discover multiple avenues of support, which aligns with the finding that experience (year of study; β = 0.188) moderates CAAD use.

Social influence is partly captured through curriculum integration (β = 0.249), which, in a mandatory educational context, serves as an authoritative social norm compelling CAAD engagement. This is consistent with Venkatesh et al.'s (2003) prediction that social influence is stronger under mandatory use conditions and in contexts where subjects have limited prior experience.

UTAUT moderators, gender (β = 0.085), age (β = 0.073), and experience (operationalised as year of study, β = 0.188, and educational attainment, β = 0.159), are all significant, consistent with Venkatesh et al.'s (2003) moderation predictions. The findings confirm that gender and age moderate performance expectancy in the behavioural intention to use technology, with this moderation stronger for men and younger users (Morris & Venkatesh, 2000; Venkatesh & Morris, 2000). Cespedes (2008) argued that

design students entering higher education in the twenty-first century are digital natives for whom technology is a natural medium, and this orientation is consistent with the finding that younger students in this sample are more advanced CAAD users.

5.3 The Negative Printer Beta: A Counterintuitive Finding

The large-format printer variable has the largest absolute beta in the use model ($\beta = -0.316$, $p < .001$), and it is negative—the only negative predictor. This is counterintuitive: one might expect better printing facilities to support more extensive CAAD use. Two hypotheses merit exploration in future research. First, a resource-substitution effect may be at work: institutions that invest in plotters may be diverting resources from direct computing infrastructure, resulting in fewer computers, older machines, and lower CAAD proficiency despite better printing. Second, a pedagogy-style effect may be present: the availability of plotters may signal a drawing-board-oriented curriculum culture that emphasises the output of physical drawings rather than the digital design process, subtly discouraging deeper CAAD engagement. This finding reinforces the importance of computing and studio infrastructure, rather than peripheral output devices, as the primary determinants of CAAD proficiency.

5.4 Unexplained Variance and Research Gaps

It is important to note that the acceptance model leaves 45.8% of acceptance variance unexplained, and the use model leaves 61.3% unexplained (Uwakonye, 2018, pp. 129–131, Tables 5.1–5.2). This suggests that significant determinants of both CAAD acceptance and use remain unidentified, a gap this study explicitly flags as an open agenda for future research. Candidate variables not captured in this study include students' personal computing access, internet connectivity and quality, personal motivation and self-efficacy, the quality of CAAD instruction (lecturer expertise and teaching methodology), peer influence networks, and access to online learning resources. Future studies employing structural equation modelling (SEM) or mixed-methods approaches may better account for the unexplained variance and further elucidate the causal pathways between UTAUT constructs and CAAD outcomes.

6. Implications

6.1 Implications for Curriculum Design

The study confirms that CAAD curriculum integration is the second strongest predictor of CAAD use ($\beta = 0.249$) and that 82% of students who were taught CAAD as a formal course actively use it. This provides strong empirical justification for the recommendation that CAAD should be introduced at Year 1 of architectural programmes in Nigerian universities, consistent with international norms (Koutamanis et al., 1993, as cited in Uwakonye, 2018) and the practice documented by Asperl (2005) in Austria, where 85% of secondary school students study CAD. The year of study as a significant predictor of significant use ($\beta = 0.188$) confirms that the longer students are exposed to CAAD, the more proficient they become, a finding consonant with Murray and Haubl's (2003) Power Law of Practice. The study recommends the

progressive integration of AutoCAD at Year 1, SketchUp at Year 2, Revit at Year 3, and 3ds Max at Year 4, with Building Information Modelling (BIM) workflows at Years 5–6 (Uwakonye, 2018, p. 134).

6.2 Implications for Infrastructure and Institutional Policy

Facilitating conditions, the composite resource base, are confirmed as significant CAAD use predictors. The exceptionally high correlation between power supply hours and CAAD proficiency ($r = .888$, $p \leq .01$) represents perhaps the most policy-actionable finding of this study: the single most powerful determinant of CAAD proficiency in Nigerian architecture schools is the reliability of electrical power supply. This implicates the energy infrastructure deficit as a structural barrier to digital design education in the Nigerian higher education system, with consequences extending far beyond architectural education to the broader digital economy. Universities and government bodies must prioritise investment in reliable power supply, CAAD studio capacity, and e-studio provision as preconditions for achieving the objectives of the Nigerian National ICT Policy (Federal Republic of Nigeria, 2012).

6.3 Implications for Policy and Accreditation

The findings call for direct reform of the accreditation conditions set by the National Universities Commission (NUC) and the regulatory bodies of architectural education, the Nigerian Institute of Architects (NIA) and the Architects Registration Council of Nigeria (ARCON). The study recommends that conditions for the accreditation of architecture programmes should explicitly require: a dedicated CAAD studio of adequate capacity; e-studio provision for extended student access; adequate and uninterrupted electrical power supply; qualified CAAD teaching staff in sufficient numbers; and CAAD courses at the first year of the programme (Uwakonye, 2018, p. 134). These evidence-based accreditation standards would operationalise the Nigerian National ICT Policy within the architectural education sector.

6.4 Implications for Awareness-Raising

The dominance of awareness ($\beta = 0.674$) as the sole CAAD acceptance predictor implies that targeted awareness campaigns, through faculty demonstrations, student peer-learning networks, industry-university collaboration programmes, and the dissemination of research such as the present study, represent the highest-leverage, lowest-cost intervention available to policymakers, university administrators, and professional bodies seeking to accelerate CAAD adoption in Nigerian schools of architecture. The NIA and ARCON are well placed to champion such campaigns as part of their educational development mandates.

7. Conclusion

This study presents the first multi-university, UTAUT-grounded empirical investigation of CAAD acceptance and use among architecture students in Nigeria. The findings validate UTAUT's core constructs, particularly social influence (curriculum mandate), facilitating conditions (resource base), and moderating effects of gender, age, and experience in the context of professional design education in

a developing economy, while revealing an important deviation: awareness, operationalised as Rogers' (1995) IDT observability, dominates CAAD acceptance at a level not predicted by the UTAUT framework's standard hierarchy. The acceptance model explains 54.2% of variance through awareness alone, while the use model explains 38.7% through ten predictors encompassing experience, curriculum, infrastructure, and socio-demographic moderators.

The 45.8% and 61.3% unexplained variance in the acceptance and use models, respectively, constitute a rich agenda for future research, one that this study explicitly calls upon scholars, particularly those in sub-Saharan Africa, to pursue. The authors further recommend the establishment of a regional body, the African Association of Education and Research in Computer-Aided Architectural Design (AfriCAAD), to provide an institutional platform for the propagation of CAAD research in sub-Saharan Africa, analogous to the established bodies in North America (ACADIA), Europe (eCAADe), Asia (CAADRIA), South America (SIGraDi), and the Arab world (ASCAAD), and to coordinate the regional research programme that the open questions from this study demand.

Ultimately, the findings of this study are clear in their policy implications: to raise the acceptance and use of CAAD in Nigerian architectural education, institutions must simultaneously pursue awareness campaigns, reform the curriculum to introduce CAAD earlier and more systematically, and invest urgently in the computing, spatial, and energy infrastructure without which even the most committed students cannot develop the digital design proficiency their professional future demands.

Declarations

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Conflicts of Interest

The author declares no conflict of interest.

Data Availability

The dataset supporting the findings of this study is available from the corresponding author on reasonable request.

Ethical Approval

The study was conducted in accordance with the Declaration of Helsinki. Institutional ethical clearance was obtained from Covenant University, Ota, and informed consent was secured from all participants. Participation was voluntary, and responses were anonymised.

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