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COMPUTER-AIDED DESIGN IN ARCHITECTURAL EDUCATION: IMPLEMENTATION AND PERCEPTION BY ARCHITECTURE STUDENTS IN MINNA, NIGERIA

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ABSTRACT

The integration of computer-aided design (CAD) technology in architectural education has garnered substantial attention for enhancing learning outcomes. This study examines CAD's deployment as a learning medium in the Department of Architecture at the Federal University of Technology (FUT) in Minna, Nigeria. By assessing CAD awareness, utilisation, and perceptions among students, it offers insights into its educational effectiveness. Recognising CAD's importance in architectural practice, the study critically evaluates its pedagogical implementation. It addresses multifaceted concerns, including CAD integration in design courses, associated pros and cons, and its influence on student performance. Identifying gaps, the study aims to optimise CAD integration, fostering comprehensive architectural education. With objectives spanning CAD awareness, utilisation, and academic impact, this quantitative research adopts descriptive

Introduction

The impact of technology in these days and age on all human endeavours remains unavoidable. Similar to every field and profession, the technological revolution being experienced has a huge impact in the field of architecture and architectural design (Al-Matarneh & Fethi, 2017). The principle of such innovations in the field of architecture is computer-aided design (CAD). The integration of computer-aided design (CAD) technology in architectural education has garnered significant attention due to its potential to enhance learning outcomes and design processes. This study focuses on evaluating the deployment of CAD as a medium for teaching and learning architectural design within the Department of Architecture at FUT Minna, Nigeria.

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and correlational designs. Involving students underscores the need for seamless CAD integration and a balanced approach combining manual skills and CAD efficiency. Addressing cost and electricity concerns, the study suggests cost management and energy-efficient practices. In conclusion, this study illuminates and strategically recommends CAD for its potential to elevate design instruction, enhance academic performance, and equip students for future careers.

Keywords: architectural design, architectural education, architectural students, computer aided design, Nigeria.

By examining the awareness, utilisation, and perceptions of CAD among students, this research aims to provide insights into the effectiveness of CAD in architectural education.

Despite the widespread recognition of CAD's importance in architectural practice, there is a need to assess its implementation as a pedagogical tool. This study addresses the following concerns: the level of awareness and utilisation of CAD in architectural design courses and its impact on students' academic performance. By identifying gaps and challenges, this research seeks to offer recommendations for optimising the integration of CAD to ensure a comprehensive and effective architectural education at the FUT Minna. Thus, the objectives of this paper are to: (i) study the level of awareness and utilisation of AutoCAD software among students of architecture at FUT Minna; (ii) evaluate the advantages and disadvantages of using AutoCAD software as a medium of learning architectural design at FUT Minna (iii) recommend how best to deploy AutoCAD software as a medium for learning architectural design at FUT Minna.

Literature Review

The design and planning of human habitations is a practice that has been in existence for a very long time. As humans' civilization grew in both intelligence and intellectual capability, knowledge and skill were streamlined into professions that required some level of training. This gave birth to the profession of architecture, which is one of the oldest professions known to man, which makes the profession an important variable in architectural education (Ofide & Muhammed, 2017). With the emergence of the computer age, technology has become an important aspect of not just the architectural profession but also how students are trained in architectural schools and departments. This is why

educational institutions globally are under pressure to use information and communication technology in the training of students, which equips the students with the required skills for the 21st century (UNESCO, 2009).

Kara (2014) posited that, in making the skills of students marketable, they must be up-to-date in the use and understanding of the digital technology widely used in practice. That is why, in the past decade, digital technologies have been highly considered in the design of curricula for training architecture students. CAD is software produced by an American company. Autodesk is the most popular CAD package used in Nigeria and many other countries. It is very important to most professionals in the built environment. It can be used to produce drawings in both 2D and 3D formats (Oyebode et al., 2015). According to Pektas & Erkip (2006), proficiency in CAD has become a skill that has become largely desirable in most architectural offices and firms these days. In addition to this, architects and chief executive officers (CEOs) of architectural firms, construction companies, and even government agencies highly value employees' ability to produce drawings and presentations in a digital format.

For this very reason, students must inculcate digital skills like CAD as part of their training before venturing into the employment market. More so, the university teachers and instructors must have the same skills for effective teaching. Similarly, Wang (2010) emphasised that teachers having digital skills like CAD not only improve the individual skills and knowledge of the teacher or instructor, but they also simplify the delivery of knowledge to the students in an organised manner. This helps the students understand the course and improve their practical abilities. In the past, students and instructors had different attitudes towards the use of CAD for studio work. Educators were more unwilling to accept it as a means of teaching and learning architectural design.

A study by Basa and Senyapili (2005) revealed that architectural design instructors hate accepting digital design presentations from students. Over time, the level of acceptance of digital design tools like CAD designs by teachers and instructors has improved. A study by Fakhri et al. (2021) showed that educators responded with a positive attitude towards the use of CAD for obvious reasons like speed, accuracy, neatness, and enhanced presentation. Furthermore, the advantages of using CAD go beyond just the actual drafting process. Rather, the deployment of CAD as a medium for teaching and learning architectural design impacts positively on the entire design process (Achten, 2000).

Achten (2000) goes further to list the processes as (i) sketches (conceptual sketches stage), (ii) preliminary design (detailed sketches stage), (iii) definitive design stage (detailed presentation drawings stage), and (iv) final design stage (working drawings stage). Just like any endeavour in life, the use of CAD and other forms of digital tools for architectural design has not only advantages but also some challenges. Most arguments in this direction stem from the impact of CAD on creativity. Pallasmaa (2005) posits that the use of CAD as a teaching and learning tool was received with anxiety by many educators because they were concerned that it would affect the creativity of students and make them lazy.

Kara (2014) further argued that while the design and production of drawings are tilting towards digital tools, important aspects of design, such as physical models and computer-aided manufacturing (CAM), still require some physical interaction with real space. However, Senske (2014) stated that some of the challenges associated with the use of digital tools like CAD can be limited by designing specialised teaching techniques like using soft learning skills. The use of CAD in the context of architectural education in Nigeria is a process that is still ongoing, especially in public universities. The reason for this slow progress is a lack of adequate infrastructure, facilities, equipment, and problems that involve power supply.

Many universities still lack the required computer-to-student ratio. This forces students to obtain their own computers and learn practical CAD skills on their own (Maina, 2008). For quick progress to be made, such facilities must be provided by universities and other training institutions. In a 2016 study by Magaji and Muhammad, they recommended an aggressive investment in information and communication technology (ICT) infrastructure and equipment. This is even more so, as the National University Commission's (2022) Core Curriculum Minimum Academic Standards (CCMAS) for Nigerian universities was very clear about the use of contemporary teaching methods and the use of technology as one of its objectives. Fulfilment of all their objectives is what, in the near future, guarantees accreditation for architectural programme in Nigerian universities.

The FUT Minna, like all universities in Nigeria, operates a 5-year architectural undergraduate degree Programme and a year and half master's degree programme. The study years are expressed from 100 to 600. Upon graduation, the students are awarded a Bachelor of Technology Degree in Architecture (B-

Tech) and a Masters of Technology Degree in Architecture (M-Tech) (Department of Architecture, FUT Minna, 2021).

METHODOLOGY

Research Design and Data Collection

The research approach employed for this study is quantitative in nature. The research design type is based on descriptive and correlational designs. The survey method was used as a means of data collection. The research instrument that was used was questionnaires, through which primary data were collected. It entails the distribution of questionnaires to respondents for a survey of their opinions. The questionnaire consists of 13 sections labelled A to M. A total of 295 questionnaires were printed for the survey. They were divided into five main groups of students. The two groups were sampled simultaneously, and the results were analysed for diligent presentation.

Population of Study and Sampling

The population of study is the staff and students of the department of architecture at FUT Minna. The sampling technique is based on probability sampling, where the respondents were selected randomly. A formula by Khan (2023) was adopted to calculate the sample size, as presented below:

$$\text{Sample Size} = \frac{\frac{Z^2XP(1-P)}{e^2}}{1+\frac{(Z2xP(1-P))}{e^2N}}$$

Where n = sample size, N = population size, Z = Z score, e = margin of error, and P = standard deviation. The percentage of the sample size in the total population was used to calculate the sample for each stratified group, which sums up to the total sample calculated.

$$\text{Sample Size} = \frac{\frac{2.58^2 \times 0.5(1-0.5)}{0.05^2}}{1+\frac{(2.58^2 \times 0.5(1-0.5))}{0.05^2 \times 613}}$$

Sample Size = 319.25

The sampling method used is stratified and simple random sampling, where the students are first divided according to their level (year of study). Then simple random sampling was used to select the respondents without any special consideration. The formula adopted from Khan (2023) to determine the sample size for each group resulted in a total sample size of 295 (Table 1).

Table 1: Population of Study

SN	Stratified Group	Population	Sample	Rate of Return	Rate of Return(%)
1	200 Level	152	79.04	73	92.3
2	300 Level	154	80.08	73	91.1
3	400 Level	66	34.32	32	93.2
4	500 Level	160	83.20	77	92.5
5	600 Level	81	42.12	39	92.5
Total		613	319	292	92.32

The rates of return for the questionnaires are 100% for students. The rate of return was excellent because the researcher waited to collect the questionnaires after disbursing them. The data analysis method used for the analyses of this study is descriptive analysis and factor analysis using the Statistical Package for Social Sciences (SPSS). The results were adequately tested with KMO and Bartlett's test before factor analyses were deployed. The research instruments were subjected to criticism and input from senior colleagues, and all gaps identified were corrected before distribution. The reliability of the questionnaires was determined, and the average Cronbach alpha value obtained is 0.82, which shows that the result is reliable.

RESULTS AND FINDINGS

Table 2 presents the results of the demographic background of the respondents to this study. A total of 227 are male and 68 are female, leading to a percentage of 77% and 23%, respectively. Among the respondents, 100% had obtained an SSCE certificate, which is a necessity for admission to the university; 1.6% had an NCE; 7.7% had a national diploma; 1% had an HND; and 13.2% were graduates of their first degree. In terms of age distribution, 73.1% were aged 15–25, 20.8% were aged 26–36, and 2.9% were aged 37 and above. As for educational levels,

23.4% were in their 200L, 23.7% were in their 300L, 10.4% were in their 400L, 24.7% were in their 500L, and 12.7% were in their 600L.

Table 2: Demographic Information of the respondents

Variables	Frequency	Percentage
Gender		
Male	227	77
Female	68	23
Educational Qualification		
SSCE	295	100
NCE	5	1.6
ND	23	7.7
HND	3	1.0
	39	13.2
Age		
15-25	225	75
26-36	64	22
37- above	6	3
Level		
200L	72	23.4
300L	73	23.7
400L	32	10.4
500L	76	24.7
600L	39	12.7

Research question one tries to find out the level of awareness and utilization of CAD as a medium of learning among students. Table 3 shows a significant frequency of 92.5 saying CAD was introduced to them as a standalone course at 200 levels. This shows the course was introduced early as a standalone course but not utilised for the architectural design course otherwise known as Studio. Most of the students felt this was an anomaly, as 89% felt CAD should be introduced to them as a means of learning architectural design at 200 levels. At this time, the students are being introduced to Architectural Design 1, otherwise known as Studio 1. As a means of presentation and assessment of design, 53% of the students felt CAD should be utilised, while 5.2% felt it should only be allowed at 400 levels. Table 3 presents the results of the level of awareness and utilisation of CAD software among respondents (i.e., the architecture students).

Table 3: Level of awareness and utilisation of CAD software among respondents

Variable		Frequency (Percentage)
At what level were you introduced to CAD	Not applicable 200L 300L 400L	16 (5.2) 285(92.5) 5(1.6) 2(0.6)
At what level did you think architecture students should be introduced to CAD as a medium of learning architectural design	Not applicable 200L 300L 400L	16 (5.2) 274(89) 16(5.2) 2(0.6)
At what level did you think architecture students should be introduced to CAD as a means of design presentation and assessing students	Not applicable 200L 300L 400L 500L	16(5.2) 166(53.9) 105(34.1) 16(5.2) 5(1.6)
What method do you think is best adopted for teaching Architectural Design	Not applicable Manual CAD Hybrid None	16(5.2) 23(7.5) 160(51.9) 108(35.1) 1(0.3)

To evaluate the advantages and disadvantages of the deployment of CAD as a medium for teaching and learning architectural design, The KMO and Bartlett's test was carried out with the total variance explained and the rotated factor matrix carried out. Table 4 presents the results from the KMO and Bartlett's tests. The KMO test yielded a high value (0.838), indicating ample sampling adequacy.

Table 4: KMO and Bartlett's test on CAD deployment for architectural design teaching and learning		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.838
Bartlett's Test of Sphericity	Approx. Chi-Square	1968.702

	Df	78
	Sig.	.000

Additionally, Bartlett's test was statistically significant (Chi-Square = 1968.702; df =78; Sig. <0.001), suggesting substantial correlations among variables. This confirms the reliability of the data for conducting factor analysis. Thus, the extraction method was used to determine the principal axis factoring. The result in Table 5 shows the outcome of the factor analysis, which explained the total variance of the data with 13 factors.

Table 5: Total Variance Explained

Factor	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.356	33.508	33.508	4.018	30.908	30.908	3.969	30.530	30.530
2	3.053	23.483	56.991	2.433	18.714	49.622	2.482	19.091	49.622
3	1.121	8.624	65.615						
4	.932	7.171	72.787						
5	.600	4.615	77.402						
6	.559	4.296	81.698						
7	.503	3.869	85.567						
8	.450	3.460	89.027						
9	.416	3.197	92.224						
10	.361	2.775	94.999						
11	.287	2.205	97.203						
12	.206	1.583	98.786						
13	.158	1.214	100.000						

The first three factors contributed significantly to the cumulative variance (65.615%), indicating their relevance in representing the underlying structure. However, as the number of factors increased, their explanatory power diminished rapidly. Therefore, the factors beyond the third one were discarded as they might not be practically meaningful or useful in interpreting the data. Hence, the result was focused on the crucial initial factors to gain valuable insights and disregard the subsequent ones to avoid overfitting or misinterpretation. Table 6 shows the outcome of the extraction method of the principal axis factoring carried out using the rotation method of varimax with Kaiser normalization. According to the table, findings show that factor 1 consists of the advantages of using CAD, which include enhancing the teaching and learning of architectural design, bringing about improvement in the design after using CAD, bringing about improvement on the graphics of students, acting as a

means of assessing and evaluating students, bringing about improvement on the design and drawing speed of students, and lastly, the drawing and design with CAD makes students more hardworking. Meanwhile, factor 2 consists of the disadvantages of using CAD, which include (i) the cost of printing, (ii) the availability of power/electricity, (iii) the availability and cost of printing, (iv) the availability of original software, (v) projection/presentation equipment, (vi) computer availability, and (vii) the availability of teaching staff.

Table 6: Rotated Factor Matrix of advantages and disadvantages of using CAD

Advantages and disadvantages of using CAD	Factor	
	1	2
CAD goes a long way in enhancing the teaching and learning of Architectural design	.886	-.027
I noticed improvement on my design/drawing speed after I started using CAD	.875	-.003
I noticed positive impact on my design after I started using CAD	.860	-.032
CAD should be used as a means of assessing and evaluating students	.779	-.121
I noticed improvement on my graphics after I started using CAD	.747	.036
Designing/Drawing with CAD makes students more hardworking	.689	-.034
Cost of printing is the biggest problem in the use of CAD in learning architectural design	.000	.663
Power/electricity availability is the biggest problem in the use of CAD in learning architectural design	-.081	.657
Availability and cost of printing is the biggest problem in the use of CAD in learning architectural design	-.014	.612
Original software availability is the biggest problem in the use of CAD in learning architectural design	-.164	.587
Projection. Presentation equipment availability is the biggest problem in the use of CAD in learning architectural design	.011	.585
Computer availability is the biggest problem in the use of CAD in learning architectural design	-.008	.544
Teaching staff availability is the biggest problem in the use of CAD in learning architectural design	.055	.485
Extraction Method: Principal Axis Factoring, Rotation Method: Varimax with Kaiser Normalization.		
a. Rotation converged in 3 iterations.		

The usefulness of CAD software in improving the academic performance of the respondents was examined, and the results of the respondents' opinions and how they felt about it were presented. The data was analysed using the relative importance index, with the result yielding mixed responses. Approximately 56.3% of respondents supported CAD as an evaluation tool, 12.5% remained neutral, and 31.3% disagreed. Similarly, 50.1% believed that CAD made students lazy, 18.8% were neutral, and 31.3% were in disagreement. However, a significant majority (81.3%) agreed that CAD enhanced the learning of architectural design, while 18.8% disagreed. Interestingly, most respondents (81.5%) rejected the idea of solely relying on manual drafting for teaching architectural design, but 12.5% supported it. An overwhelming 100% agreed on the importance of using hybrid approaches, combining both manual and CAD methods for learning architectural design. Regarding student performance, 50% of respondents praised manual drawing skills, while 43.8% considered them average. As for CAD, 50% acknowledged good performance, 31.3% rated it average, and 12.5% deemed it poor. Overall, the results demonstrate a need for careful integration and balance of manual and CAD approaches in architectural design education, considering the differing opinions and perceptions.

Discussion

Integration of auto cad is important as a major aspect of the results above showed. This importance stems from the emergence of computer technology taking over most fields of endeavour. This point agrees with the vision of UNESCO for integrating technology in all aspects of education that will prepare them for the 21st century. This fact also agrees with a study by Kara who emphases that the marketability of skills in contemporary times is highly dependent on digital literacy.

From the results in Table Three, many students felt CAD should be introduced for in-studio (Architectural Designs) works at an early stage. The result agrees with a study by Wang which posited that introducing such CAD skills makes the delivery of knowledge easier and more effective. Like any human endavour no matter how important, CAD has both advantages and disadvantages as shown in table six. Achten and Pallasma in a study agreed with this fact, stating their concerns about the utilisation of technology on student's creativity and making the students lazy.

From the results above an overwhelming 81% of the respondents agreed that CAD can enhance the learning of architectural designs. Achten in a study saw it as a force for good that outweighs the bad and will have a tremendous impact on the entire design process and digital skills of students.

CONCLUSION

The evaluation of the deployment and perception of computer-aided design (CAD) as a medium for learning architectural design at the Department of Architecture, Federal University of Technology Minna, Nigeria, reveals significant insights. The study involved 295 respondents. While CAD was introduced early as a standalone course, its utilization for architectural design courses (Studio) was limited. Most students expressed the need for CAD to be integrated into the teaching and learning process. The factor analysis highlighted the advantages and disadvantages of using CAD, emphasising its potential for enhancing design, assessment, and students' work speed. However, concerns related to costs, electricity availability, and equipment were raised. The survey results on CAD's usefulness in improving academic performance showed mixed opinions, with a majority agreeing on the importance of using a hybrid approach (both manual and CAD methods) for teaching architectural design. The following recommendations are made: (i) Enhance Integration: The Department should ensure the seamless integration of CAD into architectural design courses to maximise its potential benefits. Providing adequate training and support to staff and students in effectively using CAD tools is essential (ii) Cost Management: To address concerns about costs, the university should explore options for subsidised printing and access to original software. Additionally, energy-saving measures should be adopted to address concerns about electricity availability (iii) Hybrid Approach: Promote a balanced approach to learning architectural design by combining both manual and CAD methods. Emphasise the importance of honing manual drawing skills while leveraging the advantages of CAD for efficiency and precision (iv) Continuous Feedback: Regularly seek feedback from both students and staff regarding the use of CAD in architectural design education. This feedback will help identify areas for improvement and address any challenges that arise (v) Research and Innovation: Encourage research and innovation in the application of CAD for architectural design. Explore opportunities for collaboration with industry professionals and researchers to stay up-to-date with best practices and advancements in CAD technology. By

implementing these recommendations, the Department of Architecture can optimise the use of CAD as a valuable medium for teaching and learning architectural design, fostering improved academic performance, and equipping students with essential skills for their future careers in the field.

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