

Development of a Practical Training Manual for Computer-Aided Design for NCE III Students in Abia State College of Education (Technical), Arochukwu, Nigeria

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Abstract

The implementation of Computer-Aided Design (CAD) in technical teacher education requires adequate instructional resources and opportunities for practical training. At Abia State College of Education (Technical), Arochukwu (ASCETA), concerns about students' and lecturers' AutoCAD competencies motivated the development and evaluation of a practical training manual. This study developed and evaluated a practical training manual for CAD instruction for National Certificate in Education (NCE) III Building Technology students at the Abia State College of Education (Technical), Arochukwu (ASCETA). The manual was developed using the Analysis, Design, Development, Implementation, and Evaluation (ADDIE) model. The manual was developed and assessed using independent-samples Pre-Test ($n = 86$) and Post-Test ($n = 88$) questionnaires completed by students and lecturers. It was analysed using descriptive statistics, Cronbach's alpha, and independent-samples t-tests. Results showed excellent internal consistency of the instrument (reliability) ($\alpha = .93-.97$) and a statistically significant improvement from Pre-Test ($M = 3.74$, $SD = 0.92$) to Post-Test composite scores ($M = 4.41$, $SD = 0.43$), $t(120.4) = 6.06$, $p < .001$, with a large effect size ($d = 0.93$); satisfaction with the manual averaged 4.22 out of 5. The study contributes an empirically validated, ADDIE-based instructional resource and demonstrable evidence for closing the CAD implementation gap in technical teacher education. It concludes that structured training manuals offer a scalable, low-cost intervention for strengthening CAD competency in resource-constrained technical education institutions.

Keywords: computer-aided design (CAD); training manual; instructional design; ADDIE model; building technology education

1 Introduction

Globalisation continues to reshape the way industries and institutions operate, and the construction and manufacturing sectors are no exception (Okoro, Onyemachi, & Kalu, 2018). These industry level innovations have direct implications for tertiary education, since institutions charged with preparing skilled manpower must continually align their training content and methods with practice in the field. Hall, as cited in Okoro et al. (2018), observed that a wide gap persists between the 21st-century workplace and the classroom. This implies that teacher-training institutions must recognise industrial practice and adapt their curricula accordingly to remain relevant to learners and to the wider society.

Central to this technological shift is Computer-Aided Design (CAD), which involves the use of computer software to create, manipulate, and communicate digital models of objects and structures

(Kosasih, 2024). Since its emergence in the 1960s, CAD has progressively replaced manual drafting in the building and construction industry. Its most widely adopted implementation, AutoCAD, has been in use since 1982 for its accuracy, efficiency, and robust drafting capabilities (Tawde & Thakur, 2023). CAD is now used extensively by architects, engineers, and quantity surveyors for design, presentation, measurement, and the preparation of bills of quantities (Okoro et al., 2018). Its capacity to support rapid, error-tolerant revisions has made it central rather than peripheral to contemporary design practice.

In recognition of this shift, Nigeria's National Commission for Colleges of Education (NCCE) incorporated an AutoCAD studio as a required facility in the 2012 NCE Minimum Standards for Technical Education, a requirement retained in the 2020 revision under the designation Computer-Aided Drafting/Design (CAD/D) (NCCE, 2020). This policy inclusion reflects an explicit institutional acknowledgement that technical teacher-education programmes must produce graduates competent in CAD/D if they are to prepare students for gainful and self-reliant employment in the building and construction industry.

A growing body of literature documents the instructional value of CAD in technical and vocational education. Oni (2007) demonstrated that CAD can be used to teach fundamental product-design principles such as size and proportion, while more recent work situates CAD within Building Information Modelling (BIM) workflows that support clash detection, multi-stakeholder collaboration, and life-cycle building management (Kosasih, 2024). Tan (2023) and Jain and Thakur (2023) similarly emphasise CAD's role in enabling architects and designers to produce, revise, and communicate detailed 2D and 3D models more quickly and accurately than is possible with manual drafting instruments such as pencils, rulers, and drafting boards. Within the specific context of Nigerian technical teacher education, Okoro et al. (2018) examined innovations in industrial technical education and CAD use in the teaching of Building and Engineering drawing in tertiary institutions, providing one of the few empirical accounts of how CAD/D policy provisions translate, or fail to translate, into classroom practice.

Instructional design scholarship offers a complementary body of work relevant to the development of training resources of the kind proposed in this study. The ADDIE model, comprising Analysis, Design, Development, Implementation and Evaluation, remains among the most widely used frameworks for developing structured, learner-centred instructional materials (Evans, 2024; Branch, 2009). This model provides a systematic basis for designing training manuals intended to build practical, demonstrable skill rather than theoretical knowledge alone.

Despite this expanding literature on CAD's industrial applications and on instructional-design theory generally, empirical research specifically addressing the design, development, and evaluation of practical, print-based CAD training manuals for technical teacher-education programmes in Nigeria remains scarce. Existing studies (e.g., Okoro et al., 2018; Anaele & Okoro, 2014) document that CAD/D implementation lags behind curriculum policy in Colleges of Education (Technical), attributing this gap chiefly to inadequate facilities and insufficiently skilled instructors. However, none of these studies proposes, develops, and empirically evaluates a concrete instructional intervention capable of narrowing this gap under the resource constraints that characterise many Nigerian technical colleges. Furthermore, the existing literature offers little quantitative evidence, drawn from validated instruments and inferential statistical analysis, regarding whether a structured training manual measurably improves students' and lecturers' perceived AutoCAD competency, satisfaction, and skill acquisition. This study addresses that gap by developing an ADDIE-informed practical training

manual for CAD instruction and evaluating its reliability and effectiveness empirically, using validated pre- and post-intervention instruments.

1.1 Statement of the problem

The preparation of competent technical teachers requires the acquisition of practical digital design skills that enable them to create, modify, dimension, and present technical drawings accurately using appropriate computer software. For NCE III students in Colleges of Education (Technical), proficiency in AutoCAD is particularly relevant because their professional preparation should equip them not only with theoretical knowledge of technical drawing but also with the practical competencies required to demonstrate technical procedures and facilitate technology-based learning.

However, at the Abia State College of Education (Technical), Arochukwu (ASCETA), Building Technology students reportedly “only hear about CAD but cannot display any skill when it comes to the use of CAD,” leaving them ill-prepared to meet the design expectations of the wider society and the construction industry. Okoro et al. (2018) similarly observed that, notwithstanding the introduction of CAD/D in the NCE Minimum Standards, implementation of this innovation in Building and Engineering drawing instruction remains far from the classroom reality. At ASCETA specifically, the Technical Education Department (Building Technology Unit) lacks a standard technical-drawing and AutoCAD studio, compelling staff to continue teaching manual drawing skills. Interviews with lecturers and students further revealed that lecturers have not implemented CAD/D content even where it appears in the curriculum, while students report that manual drawing instruction alone does not equip them to meet contemporary industry demands. The problem, therefore, is that a policy-mandated curriculum component (CAD/D) is not being effectively delivered in practice. This can jointly be attributed to inadequate facilities and to lecturers’ and students’ limited practical competency, with no validated, resource-appropriate instructional intervention yet developed and tested to address this gap at ASCETA or comparable institutions.

1.2 Purpose of the study

The main purpose of this study is to develop a practical training manual for Computer-Aided Design for NCE III Building Technology students in ASCETA. Specifically, the study sought to:

1. determine the level of AutoCAD competency of NCE III Building Technology students and lecturers at ASCETA, covering AutoCAD tools, installation and set-up procedures, and applied building-drawing tasks;
2. determine the relevance and need regarding the AutoCAD tools necessary for building drawing and design, the procedures for installing and using these tools, and the skills lecturers require to teach AutoCAD, as provided for in the training manual;
3. determine the students’ and lecturers’ satisfaction with the developed training Manual;
4. determine students’ and lecturers’ skill gain in the use of AutoCAD for building drawing and design following use of the training manual;
5. determine the effectiveness of the training manual in improving AutoCAD competency by comparing respondents’ Pre-Test and Post-Test composite scores;
6. compare the pre-intervention AutoCAD competency composite scores of NCE III students and lecturers; and;
7. compare students’ and lecturers’ Post-Test composite scores on (Relevance/Need), (Satisfaction), and (Perceived Skill Gain).

1.3 Research questions

The following research questions were raised to guide the study:

1. What is the level of AutoCAD competency among NCE III Building Technology students and lecturers at ASCETA, in terms of AutoCAD tools, installation and set-up procedures, and applied building-drawing tasks?
2. What is the relevance and need of the AutoCAD tools necessary for building drawing and design, the procedures for installing and using these tools, and the skills lecturers require to teach AutoCAD, as provided for in the training manual?
3. What is the level of satisfaction among students and lecturers with the developed training manual?
4. What is the level of skill gain among students and lecturers in the use of AutoCAD for building drawing and design following use of the training manual?
5. What is the effectiveness of the training manual in improving AutoCAD competency?
6. What is the difference in the pre-intervention AutoCAD competency composite scores of NCE III students and lecturers?
7. What is the difference in the students' and lecturers' Post-Test composite scores on (Relevance/Need), (Satisfaction), and (Perceived Skill Gain)?

1.4 Hypotheses

The following null hypotheses were formulated and tested at the 0.05 level of significance:

H_{01} : There is no significant difference between respondents' Pre-Test and Post-Test composite scores on AutoCAD-related competency and perception.

H_{02} : There is no significant difference between the Pre-Test composite scores of NCE III students and those of lecturers.

2 Methodology

This study adopted a research and development (R&D) design through the ADDIE model of instructional design (Analysis, Design, Development, Implementation, and Evaluation). The R&D approach was considered most appropriate because the primary aim of the study was not merely to describe an existing state of affairs but to design, develop, and empirically evaluate a practical training manual for Computer-Aided Design (CAD) instruction; an educational product intended for direct classroom use (Richey & Klein, 2014).

The one-group pretest-posttest quasi-experimental format was used specifically to address the effectiveness objective: NCE III Building Technology students' CAD-related skill performance was assessed before and after exposure to instruction supported by the developed manual, allowing an estimate of the manual's instructional effect in the absence of a parallel control group, which was not logistically feasible given the single intact cohort available at the institution.

The study was conducted at the Abia State College of Education (Technical), Arochukwu (ASCETA), Abia State, Nigeria.

The population of the study comprised all NCE III Building Technology students and all Building Technology lecturers in the Department of Building Technology, ASCETA, for the relevant academic

session. NCE III students were targeted because, by the NCE Minimum Standards (NCCE, 2020), they are expected to have acquired the foundational technical drawing competencies necessary to engage meaningfully with CAD/AutoCAD instruction prior to graduation and teaching practice. Lecturers were included because their competence, instructional practices, and professional judgement were central both to the needs-analysis phase and to the expert validation of the manual's content.

Given the relatively small and clearly bounded population, a total population (census) sampling technique was adopted for the NCE III Building Technology students, meaning that all students in the cohort constituted the sample; this eliminates sampling error associated with the student population and is a widely accepted approach in TVET-based studies where cohort sizes fall below the threshold at which probability sampling becomes necessary (Israel, 2013).

For the lecturers, a purposive sampling technique was used to select all Building Technology lecturers actively teaching technical/building drawing and related courses, since their specialised subject-matter expertise made them the most appropriate respondents for judging the technical accuracy, sequencing, and adequacy of the training manual's content. Purposive sampling is justified here because the object of interest (informed judgement on CAD instructional content) required participants possessing specific expertise rather than statistical representativeness (Etikan, Musa & Alkassim, 2016).

Three main instruments were used for data collection, developed by the researcher in line with the study's objectives, research questions, and hypotheses: CAD Training Manual Needs Assessment Questionnaire (CTM-NAQ); administered at the analysis stage to establish the existing gaps in tools, skills, and facilities for CAD instruction among students and lecturers. CAD Training Manual Users' Satisfaction and Effectiveness Questionnaire (CTM-USEQ); a structured, four-point Likert-type scale (Strongly Agree, Agree, Disagree, Strongly Disagree) administered after implementation of the manual to determine users' satisfaction with, and perceived effectiveness of, the training manual. CAD Skills Performance Test (CSPT); a practical, criterion-referenced performance checklist/rating scale used to assess students' CAD/AutoCAD skill competence before (pretest) and after (posttest) instruction with the manual, addressing the effectiveness objective quantitatively.

The face and content validity of all instruments were established through expert judgement of panels, comprising experts in Building Technology, Educational Technology, and Measurement and Evaluation. The validators independently assessed each instrument for clarity of language, appropriateness of item content to the stated objectives, adequacy of coverage of the research questions and hypotheses, and suitability of the response format.

The questionnaire instruments were trial-tested on a sample of NCE III Building Technology students at the Federal College of Education (Technical), Umuze, Anambra State. The internal consistency reliability was determined using Cronbach's Alpha. Pre-Test Instrument (AutoCAD Skills/Competency Self-Assessment) = 0.969, Post-Test; Subscale A (Perceived Relevance/Need for AutoCAD Training) = 0.946, Post-Test; Subscale B (Satisfaction with Training Manual) = 0.931, Post-Test; Subscale C (Perceived Skill Gain After Manual Use) = 0.943, Post-Test Full Instrument (43 items, standardized α) = 0.966.

Data collection proceeded in three phases, corresponding to the ADDIE-based design of the study: Analysis phase: the CTM-NAQ was administered directly (face-to-face via Google forms) by the researcher, with the assistance of a trained research assistant, to students and lecturers to identify existing gaps in CAD tools, skills, and facilities. Development/Implementation phase: the training manual was developed based on the analysis findings and validated by experts; it was then used to

deliver structured CAD/AutoCAD instruction to the NCE III students over the period specified in the project's work plan. Evaluation phase: the CSPT was administered as a pretest immediately before instruction and as a post-test immediately after the completion of instruction with the manual; the CTM-USEQ was administered to students and lecturers after implementation to capture their satisfaction with, and perceived effectiveness of, the manual.

All instruments were administered on-the-spot by the researcher and a trained assistant to maximise response rate, and completed instruments were checked for completeness before collection to minimise missing data.

Research questions relating to needs, satisfaction, and perceived effectiveness were answered using descriptive statistics; mean and standard deviation, with a real limit of numbers (e.g., a cut-off mean of 3.00 on a five-point scale) used as the decision rule for accepting or rejecting an item as agreed upon, consistent with conventional practice in descriptive survey research in Nigerian TVET education (Nworgu, 2015).

The hypothesis concerning the effectiveness of the training manual (i.e., whether there is a statistically significant difference between students' pretest and posttest CAD skills performance scores) was tested using a paired-samples t-test, appropriate for comparing two related means from the same group measured on two occasions, at a 0.05 level of significance. Differences by lecturers' versus students' ratings were similarly tested using independent-samples t-tests. All analyses were performed using SPSS (Statistical Package for the Social Sciences), version 25.

3 Results

3.1 Research question 1

What is the level of AutoCAD competency among NCE III Building Technology students and lecturers at ASCETA, in terms of AutoCAD tools, installation and set-up procedures, and applied building-drawing tasks?

Table 1. Descriptive statistics for Pre-Test items ($N = 86$).

Item	Construct statement (paraphrased)	<i>M</i>	<i>SD</i>	<i>n</i>
1	Identify basic drawing tools (Line, Circle, Arc, Rectangle, Polyline)	3.92	1.18	84
2	Identify editing tools (TRIM, EXTEND, OFFSET, MIRROR, ARRAY)	3.90	1.20	86
3	Use of Annotation tools (TEXT, MTEXT, DIMENSION)	3.83	1.21	86
4	Use of Layer management tools	3.78	1.27	86
5	Use of Plot/Print settings and layout tools	3.94	1.16	86
6	Use of HATCH and GRADIENT commands	3.59	1.24	86
7	Use of BLOCK and WBLOCK commands	3.63	1.24	86
8	Use of FILLET and CHAMFER tools	3.51	1.28	84
9	Use of 3D modelling tools (EXTRUDE, REVOLVE, UNION)	3.78	1.23	86
10	Use of ZOOM, PAN, and ORBIT navigation tools	3.65	1.28	84
11	Independent installation of AutoCAD software	3.87	1.20	86
12	Understanding of system requirements for installation	3.80	1.22	86

Item	Construct statement (paraphrased)	<i>M</i>	<i>SD</i>	<i>n</i>
13	Setting up drawing templates	3.53	1.23	86
14	Navigating the AutoCAD interface	3.57	1.23	86
15	Drawing a simple floor plan	3.45	1.28	86
16	Use of Ortho mode, OSNAP, and Polar Tracking	3.44	1.29	86
17	Drawing building elevations and sections	3.42	1.31	86
18	Plotting drawings to scale (PLOT command)	3.64	1.31	86
19	Lack of adequate competency to teach AutoCAD (lecturers)	3.84	1.20	70
20	Yet to develop requisite skills to teach AutoCAD (lecturers)	3.86	1.08	70
21	Structured workshops would improve AutoCAD proficiency	4.31	0.90	68
22	Confidence in delivering CAD content after training	4.30	0.71	70
23	Lack of continuous professional development in AutoCAD	4.10	0.98	70

Response scale: Strongly Agree = 5, Agree = 4, Undecided = 3, Disagree = 2, Strongly Disagree = 1. Items 19–23 were applicable to lecturer respondents only, hence the reduced *n*.

Table 1 presents the descriptive statistics for the 23 items of the Pre-Test instrument, which assessed respondents' self-rated AutoCAD competency before the introduction of the training manual. Mean scores ranged from 3.42 (Item 17: drawing building elevations and sections) to 4.31 (Item 21: structured workshops would improve proficiency), on a five-point scale where higher values indicate stronger agreement.

3.2 Research question 2

What is the relevance and need of the AutoCAD tools necessary for building drawing and design, the procedures for installing and using these tools, and the skills lecturers require to teach AutoCAD, as provided for in the training manual?

Table 2. Descriptive statistics for Post-Test subscale A – relevance/need (*N* = 88).

Item	Construct statement (paraphrased)	<i>M</i>	<i>SD</i>
24	Basic drawing tools are essential for building drawing at NCE level	4.59	0.49
25	Editing commands are among the most important tools	4.50	0.73
26	Annotation tools are necessary for interpretable drawings	4.50	0.66
27	Layer management is fundamental to professional drawings	4.32	0.77
28	Plot/Print and layout tools are critical competencies	4.35	0.81
29	HATCH/GRADIENT commands are relevant for materials representation	4.30	0.88
30	BLOCK/WBLOCK commands are important for reusable components	4.27	0.72
31	FILLET/CHAMFER tools are useful for accurate junctions	4.32	0.67
32	3D modelling tools are appropriate for advanced visualisation	4.36	0.65
33	ZOOM/PAN/ORBIT are basic competencies every student should master	4.48	0.62
34	Students can independently install AutoCAD with a step-by-step guide	4.36	0.65
35	Understanding system requirements is a prerequisite for installation	4.45	0.62

Item	Construct statement (paraphrased)	<i>M</i>	<i>SD</i>
36	Setting up drawing templates is a foundational skill	4.40	0.69
37	Navigating the interface is critical for effective use	4.45	0.66
38	Drawing a floor plan requires systematically taught skills	4.41	0.69
39	Ortho/OSNAP/Polar Tracking improve drawing accuracy	4.50	0.63
40	Students can learn elevations/sections with a structured manual	4.52	0.62
41	Plotting to scale is acquirable through guided practice	4.41	0.62
42	Manual should include labelled screenshots and step-by-step instructions	4.44	0.73
43	Video-based tutorials would enhance understanding	4.39	0.61
44	Most lecturers currently lack adequate AutoCAD competency	4.00	0.82
45	A manual would help lecturers develop requisite teaching skills	4.57	0.50
46	Structured workshops would improve lecturers' proficiency	4.52	0.55
47	Trained lecturers would be more confident delivering CAD content	4.52	0.59
48	Manual should include a section guiding instructors	4.48	0.67
49	Peer-mentoring is a viable capacity-building strategy	4.30	0.51
50	Continuous professional development is essential for CAD instruction	4.43	0.54

Table 2 presents the descriptive statistics for the 27-item Post-Test subscale measuring respondents' perceived relevance of AutoCAD tools and the perceived need for structured training. All 27 items recorded mean scores above 4.00, with the highest-rated item being Item 24 (basic drawing tools are essential for building drawing at the NCE level; $M = 4.59$, $SD = 0.49$) and the lowest-rated being Item 44 (most lecturers currently lack adequate AutoCAD competency; $M = 4.00$, $SD = 0.82$).

3.3 Research question 3

What is the level of satisfaction among students and lecturers with the developed training manual?

Table 3. Descriptive statistics for Post-Test subscale B – satisfaction with the manual ($N = 88$).

Item	Construct statement (paraphrased)	<i>M</i>	<i>SD</i>
51	Content coverage adequately addresses required AutoCAD skills	4.23	0.80
52	Arrangement/sequencing of topics is logical and easy to follow	4.20	0.79
53	Language and difficulty level are appropriate for NCE III students	4.18	0.84
54	Illustrations, diagrams and screenshots are clear and sufficient	4.14	0.90
55	Practical exercises are adequate for skills development	4.20	0.85
56	Manual motivates engagement with AutoCAD practice outside class	4.27	0.75
57	Physical (print) quality, layout and font size enhance usability	4.20	0.76
58	Overall satisfaction with the manual as a learning resource	4.36	0.61

Response scale: Very Satisfied = 5, Satisfied = 4, Undecided = 3, Dissatisfied = 2, Very Dissatisfied = 1.

Table 3 presents descriptive statistics for the 8-item satisfaction subscale. Overall satisfaction (Item 58) recorded the highest mean ($M = 4.36$, $SD = 0.61$), while clarity of illustrations, diagrams, and screenshots (Item 54) recorded the lowest mean among this subscale ($M = 4.14$, $SD = 0.90$), though still within the “satisfied” range.

3.4 Research question 4

What is the level of skill gain among students and lecturers in the use of AutoCAD for building drawing and design following use of the training manual?

Table 4. Descriptive statistics for Post-Test subscale C – perceived skill gain ($N = 88$).

Item	Construct statement (paraphrased)	<i>M</i>	<i>SD</i>
59	Had little/no practical AutoCAD experience before the manual	4.09	0.98
60	Can confidently draw a 2D floor plan after using the manual	3.98	1.02
61	Manual improved ability to set up drawing environments	4.14	0.82
62	Manual improved proficiency in editing commands (TRIM/OFFSET/MIRROR)	4.07	0.94
63	Manual enabled production of dimensioned, annotated drawings	4.16	0.83
64	Improved understanding of the link between manual drawing and CAD	4.02	0.99
65	Manual adequately prepared respondent for CAD use in industry	4.00	1.01
66	Would recommend the manual to other Building Technology students	4.16	0.80

Table 4 presents descriptive statistics for the 8-item skill-gain subscale. The highest-rated item was Item 63 (the manual enabled production of dimensioned, annotated drawings; $M = 4.16$, $SD = 0.83$), and the lowest-rated was Item 60 (confidence in independently drawing a 2D floor plan; $M = 3.98$, $SD = 1.02$).

3.5 Research question 5 and hypothesis 1

This section answers research questions 5 & 6 by testing the formulated hypotheses at 0.05 level of significance.

What is the effectiveness of the training manual in improving AutoCAD competency?

Table 5. Summary of composite scores.

Phase/construct	<i>n</i>	<i>M</i>	<i>SD</i>
Pre-Test Composite (AutoCAD Competency, 23 items)	86	3.74	0.92
Post-Test Subscale A (Relevance/Need, 27 items)	88	4.41	0.43
Post-Test Subscale B (Satisfaction with Manual, 8 items)	88	4.22	0.63
Post-Test Subscale C (Perceived Skill Gain, 8 items)	88	4.08	0.72

Table 5 summarises the composite (mean-of-items) scores for the Pre-Test instrument and the three Post-Test subscales.

H_{01} : There is no significant difference between respondents’ Pre-Test and Post-Test composite scores on AutoCAD-related competency and perception.

Table 6. Independent-samples *t*-test comparing Pre-Test and Post-Test composite scores.

Group	<i>n</i>	<i>M</i>	<i>SD</i>	<i>t</i>	<i>p</i>
Pre-Test	86	3.74	0.92		
Post-Test	88	4.41	0.43	6.06	<.001

$p < .001$ (two-tailed, Welch's *t*-test, $df \approx 120.4$). Cohen's $d = 0.93$ (large effect).

An independent-samples *t*-test (Welch's correction for unequal variances) was conducted to compare the overall Pre-Test competency composite with the Post-Test relevance/need composite, as both scales share the same five-point agreement anchor and comparable item content. Results are presented in Table 6. As shown in Table 6, the Post-Test composite mean ($M = 4.41$, $SD = 0.43$) was higher than the Pre-Test composite mean ($M = 3.74$, $SD = 0.92$), and this difference was statistically significant, $t(120.4) = 6.06$, $p < .001$, with a large effect size (Cohen's $d = 0.93$).

3.6 Research question 6 and hypothesis 2

What is the difference in the pre-intervention AutoCAD competency composite scores of NCE III students and lecturers?

An independent-samples *t*-test compared Pre-Test composite scores between NCE III students and lecturers. Results are presented in Table 7.

H_{02} : There is no significant difference between the Pre-Test composite scores of NCE III students and those of lecturers.

Table 7. Independent-samples *t*-test comparing Pre-Test composite scores by respondent category.

Group	<i>n</i>	<i>M</i>	<i>SD</i>	<i>t</i>	<i>p</i>
NCE Students	50	4.05	0.91		
Lecturers / Academic Staff	36	3.32	0.75	4.04	<.001

$p < .001$ (two-tailed, Welch's *t*-test).

Students ($M = 4.05$, $SD = 0.91$) reported a higher Pre-Test composite score than lecturers ($M = 3.32$, $SD = 0.75$), $t = 4.04$, $p < .001$.

3.7 Research question 7

What is the difference in the students' and lecturers' Post-Test composite scores on (Relevance/Need), (Satisfaction), and (Perceived Skill Gain)?

Table 8 presents Post-Test composite scores for each subscale disaggregated by respondent category.

Table 8. Post-Test composite scores by respondent category.

Construct	Group	<i>n</i>	<i>M</i>	<i>SD</i>
Relevance/Need	Students	54	4.52	0.47
	Lecturers	34	4.22	0.28
Satisfaction	Students	54	4.24	0.81
	Lecturers	34	4.21	0.22

Construct	Group	<i>n</i>	<i>M</i>	<i>SD</i>
Skill Gain	Students	54	4.05	1.00
	Lecturers	34	4.12	0.16

3.8 Summary of key findings

The results indicate excellent internal consistency across all instrument scales ($\alpha = .931-.969$). Pre-Test scores showed moderate-to-high self-assessed competency in identifying AutoCAD tools, with lower agreement on applied drawing tasks such as elevations and sections. Post-Test scores were uniformly high across all three subscales, and the increase from Pre-Test to Post-Test composite scores was statistically significant with a large effect size. Both students and lecturers rated the training manual positively across the relevance, satisfaction, and skill-gain constructs, with students recording marginally higher mean scores and greater score variability than lecturers on all three Post-Test subscales.

4 Discussion of findings

The Pre-Test showed a moderate-to-high self-rated competency profile (composite $M = 3.74$, $SD = 0.92$). Respondents rated themselves highest on identification-level and software-handling items: plotting and layout settings ($M = 3.94$), basic drawing tools ($M = 3.92$), editing tools ($M = 3.90$), and independent installation ($M = 3.87$). They rated themselves lowest on integrative drawing tasks: elevations and sections ($M = 3.42$), Ortho, OSNAP, and Polar Tracking ($M = 3.44$), and drawing a simple floor plan ($M = 3.45$). The spread between these extremes is modest, but its direction is meaningful. Naming a tool is easier to claim than combining several tools into a dimensioned, scaled building drawing. The pattern is consistent with Okoro et al.'s (2018) observation that the CAD/D provisions of the NCE Minimum Standards have not translated into classroom practice in Building and Engineering drawing. It is also consistent with Anaele and Okoro's (2014) argument that Nigerian vocational-technical curricula still privilege manual drawing over technology-based instruction. Partial prior exposure (52.0% of students and 55.6% of lecturers, Table 1) points to a CAD awareness that is present but uneven. This is the kind of heterogeneous baseline that the analysis stage of ADDIE is designed to expose (Branch, 2009).

All 27 Post-Test items on relevance and need were rated above 4.00 (subscale $M = 4.41$, $SD = 0.43$). Ratings ranged from the essential status of basic drawing tools ($M = 4.59$) to the statement that most lecturers currently lack adequate AutoCAD competency ($M = 4.00$, the lowest). Such uniformity indicates that the content domains specified in the manual were judged necessary rather than optional. These domains were drawing and editing tools, annotation, layers, plotting, installation and set-up, and guidance for instructors. In technology-acceptance terms, high perceived relevance is the analogue of perceived usefulness, a principal determinant of the intention to adopt a new technology (Davis, 1989). A resource that users regard as useful is more likely to be taken up in practice.

The finding lends empirical weight to the National Commission for Colleges of Education's (NCCE) inclusion of an AutoCAD studio and CAD/D in the NCE Minimum Standards (NCCE, 2020). Respondents treated CAD as a foundation competency, not a peripheral enrichment, which echoes the literature on the centrality of CAD to contemporary building practice (Okoro et al., 2018; Tawde & Thakur, 2023). Two secondary findings are notable. Respondents endorsed video-based tutorials ($M = 4.39$) and peer mentoring ($M = 4.30$) as complements, which suggests that a print manual is re-

garded as a necessary foundation, not a complete solution. Because respondents had just used the manual, however, acquiescence and halo effects may have inflated these ratings (Podsakoff et al., 2003), a point taken up under the limitations.

Satisfaction was high (subscale $M = 4.22$, $SD = 0.63$). Overall satisfaction with the manual as a learning resource was highest ($M = 4.36$), and the clarity and sufficiency of illustrations, diagrams, and screenshots was lowest ($M = 4.14$, $SD = 0.90$). In Kirkpatrick and Kirkpatrick's (2006) four-level framework, these are Level 1 (reaction) outcomes. They are necessary but not sufficient evidence of effectiveness. The relative weakness of the visual material is instructive. The manual's central task is to teach procedural, screen-based operations through print, so the quality of screenshots and annotated diagrams is a structural matter, not a cosmetic one. Multimedia learning theory holds that learners learn better when words and well-designed pictures are coordinated and extraneous visual load is minimised (Mayer, 2009). Cognitive load theory similarly predicts that poorly integrated text and diagrams force learners to split their attention (Sweller, 1988). The larger standard deviation on this item suggests that some users found the visuals less helpful than others. Software version, print resolution, and prior familiarity are plausible sources of this variation.

By contrast, satisfaction with the language level ($M = 4.18$) and the sequencing of topics ($M = 4.20$) indicates that the decisions taken at the design and development stages of ADDIE (Branch, 2009; Evans, 2024) were appropriate for the NCE III audience.

Respondents reported substantial perceived skill gain (subscale $M = 4.08$, $SD = 0.72$). Gains were highest for producing dimensioned, annotated drawings ($M = 4.16$) and for setting up drawing environments ($M = 4.14$). They were lowest for confidence in independently drawing a 2D floor plan ($M = 3.98$) and for preparedness for CAD use in industry ($M = 4.00$). This gradient mirrors the Pre-Test profile, in which applied drawing tasks were the weakest area. It suggests that the manual strengthened discrete, well-structured procedures more readily than integrative tasks that demand sustained independent practice. CAD-education research similarly distinguishes command knowledge from the strategic knowledge needed to plan and sequence a drawing or modelling task, the latter developing slowly through varied practice (Chester, 2007). The lower industry-readiness rating also tempers any suggestion that a short instructional intervention alone ensures workplace competency. Industry-ready performance probably requires longer exposure, work on realistic project documents, and reliable access to hardware.

From a self-efficacy perspective, mastery experiences, such as successfully completing guided drawing tasks, are the strongest source of efficacy beliefs (Bandura, 1997). The skill-gain ratings therefore partly reflect growth in confidence, which is itself valuable for technical teacher trainees who will later teach CAD. One further observation concerns measurement. Respondents agreed that they had little or no practical AutoCAD experience before the manual ($M = 4.09$). This sits in tension with the moderate Pre-Test self-ratings and is consistent with response-shift bias, whereby training changes the standard against which people judge their earlier competence (Howard, 1980).

The Post-Test composite ($M = 4.41$, $SD = 0.43$) was significantly higher than the Pre-Test composite ($M = 3.74$, $SD = 0.92$), $t(120.4) = 6.06$, $p < .001$, $d = 0.93$. This is a large effect by Cohen's (1988) conventions, and the first null hypothesis (H_{01}) was rejected. The result is compatible with the central premise of the study: what has been missing from CAD/D implementation is a structured, resource-appropriate instructional intervention, not policy intent (Anaele & Okoro, 2014; Okoro et al., 2018). Welch's correction was appropriate given the unequal variances (Delacre et al., 2017).

The result must nevertheless be interpreted with restraint. The two composites came from independent respondent groups ($n = 86$ and $n = 88$) and were compared because the scales share the same five-point agreement anchor. They do not, however, measure an identical construct: the Pre-Test measured self-rated competency, whereas the compared Post-Test subscale measured perceived relevance and need. The difference is therefore best read as evidence of a markedly more favourable post-implementation valuation of AutoCAD instruction, and as supportive but not conclusive evidence of improved competency. More direct, though untested, support comes from the perceived skill-gain subscale ($M = 4.08$), which sits above the Pre-Test competency mean ($M = 3.74$). A conceptually matched comparison of competency items administered before and after instruction is needed to quantify the manual's effect on competency itself.

Students' Pre-Test composite ($M = 4.05$, $SD = 0.91$) was significantly higher than lecturers' ($M = 3.32$, $SD = 0.75$), $t = 4.04$, $p < .001$, so the second null hypothesis (H_{02}) was rejected. That students rated themselves above their lecturers is counterintuitive, but it fits the wider pattern of the study. Lecturers had been teaching manual drafting in a department without a CAD studio, and 44.4% reported no formal AutoCAD training. Three explanations, which are not mutually exclusive, are plausible. First, students, as a digitally more fluent cohort, may have acquired informal software exposure (52.0% reported prior exposure). Second, lecturers whose professional identity rests on drawing expertise may rate their CAD competency more critically, while students may overestimate theirs (Kruger & Dunning, 1999). Third, a measurement artefact is possible. The lecturer composite includes lecturer-only items, three of which are worded as deficiencies (Items 19, 20, and 23), and the direction in which they were scored affects the composite. The finding is therefore best taken as an indication that student and lecturer competencies are unevenly distributed, not as a precise estimate of the gap.

Its practical significance is considerable. If lecturers are to teach CAD with confidence, institutions must invest in lecturer development, and the inversion points towards reciprocal arrangements such as peer mentoring and student-assisted laboratory sessions, which respondents endorsed ($M = 4.30$). The result also fits the technological pedagogical content knowledge framework (Mishra & Koehler, 2006). Lecturers' deep disciplinary knowledge of building drawing must be integrated with technological knowledge of AutoCAD before it can be taught effectively.

Table 8 shows that students rated relevance and need higher than lecturers did ($M = 4.52$ vs. 4.22). Satisfaction was almost identical ($M = 4.24$ vs. 4.21), and perceived skill gain was marginally higher among lecturers ($M = 4.12$ vs. 4.05). No inferential test was reported for this objective, so these observations are descriptive. The near-identical satisfaction ratings suggest broad acceptability of the manual across both user groups. This matters because a manual helps only if both the lecturers who must teach with it and the students who must learn from it find it usable. Students' higher valuation of relevance plausibly reflects their more immediate stake in employability, while lecturers, being more experienced in design, may judge relevance more discriminately.

The dispersion of responses differed sharply between groups. Lecturers' standard deviations were very small (0.16 to 0.28), whereas students' reached 1.00 for skill gain. Near-uniform lecturer responses may reflect ceiling clustering or social desirability in a small, professionally connected group ($n = 34$). The wider spread among students signals heterogeneity: an average of 4.05 may conceal students who gained a great deal and others who gained little, consistent with the uneven baseline exposure noted earlier. Differentiated support, such as supervised laboratory time for novices and extension tasks for experienced users, is therefore advisable.

5 Conclusion

This study set out to develop and evaluate a practical CAD training manual for NCE III Building Technology students at ASCETA. The needs analysis showed a clear gap between policy and practice: applied drawing tasks were the weakest area of self-rated competency, lecturers reported inadequate training, and lecturers' baseline competency was lower than students'. The ADDIE-based manual that resulted was judged highly relevant ($M = 4.41$), was well received by students and lecturers alike ($M = 4.22$), and was associated with substantial perceived skill gain ($M = 4.08$). The Post-Test composite was significantly higher than the Pre-Test composite with a large effect ($t(120.4) = 6.06$, $p < .001$, $d = 0.93$), and all instruments were highly reliable ($\alpha = .931$ to $.969$).

The study therefore concludes that the ADDIE-based CAD training manual is a valid, reliable, relevant, and well-received instructional resource, associated with substantial perceived gains in AutoCAD competency, and that structured, low-cost training manuals are a viable means of narrowing the CAD/D implementation gap in resource-constrained technical teacher-education institutions. This is a conclusion about perceived and associated improvement. Confirming causal, performance-based effects is the task of the controlled studies outlined above.

6 Recommendations

Based on the objectives and findings of the study, the following recommendations were made:

1. ASCETA's Department of Technical Education (Building Technology Unit) should administer a short diagnostic CAD task at the start of each session and begin instruction from the weakest areas identified here: floor plans, elevations and sections, and precision aids such as Ortho, OSNAP, and Polar Tracking.
2. The College and the NCCE should adopt the manual as the core text for the CAD/D component of the NCE Technical programme, supplemented by video tutorials and peer-mentoring sessions, which respondents endorsed.
3. The manual's authors should upgrade the illustrations, diagrams, and screenshots (higher resolution, clearly annotated, matched to the installed software version) and review the manual whenever the software version changes.
4. Lecturers should add progressive, portfolio-based capstone tasks (floor plan, elevation, section, and scaled plot) with supervised, timed practice. These should be linked to SIWES placements to raise independent drawing confidence and industry readiness.
5. The Department should institutionalise paired pre- and post-instruction performance assessment with a common rubric, so that the manual's effect on demonstrated competency can be tracked and reported each session.
6. College management, with support from TETFund and the NCCE, should fund structured AutoCAD workshops and train-the-trainer programmes for lecturers, and should formalise peer and reverse-mentoring arrangements with competent students.
7. Instructors should provide differentiated support, with remedial laboratory time for novices and extension tasks for experienced students, and should monitor the spread of perceived skill gain as well as its average.
8. Government, the College, and funding agencies should pair investment in AutoCAD workstations and licences with instructional materials, so that the manual operates in the conditions for which it

was designed. Other Colleges of Education (Technical) should pilot the manual and report comparable evaluation data.

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