International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Addressing Inadequate Basic CAD Skills and Experiences among Second-Year BTLEd-HE Students through CADVENTURE: An Innovative Digitalized CAD Instructional Material

Melchor L. Belingan[1], Chiery Ann S. Contorno[2], Cheryl A. Halipa[3], Lene Gie M. Lubiano[4], Edgar Jr. S. Pania[5], Angela Jhesca Q. Sinabe[6]

[1,2,3,4,5,6]Student, Bachelor of Technology and Livelihood Education major in Home Economics, Faculty of Teacher Education, Davao Oriental State University, Mati City, Davao Oriental, Philippines

Abstract

This classroom-based action research addressed inadequate basic Computer-Aided Design (CAD) skills and experiences among second-year Bachelor of Technology and Livelihood Education major in Home Economics (BTLEd-HE 2) students of Davao Oriental State University. A diagnostic test given during problem identification showed that all students scored below the passing rate, and the pretest given at the start of the intervention showed that 19 of 24 students (79.17%) did not reach the 75% passing standard. Root cause analysis traced the problem to three causes within the teacher-researchers' control: limited practice and digital skills with CAD tools and commands, no adequate experience in CAD, and insufficient hands-on practice, learning and supervision. The intervention, CADVENTURE: An Innovative Digitalized CAD Instructional Material, is grounded in the Technological Pedagogical Content Knowledge (TPACK) framework and uses Canva, Google Drive and web-based SketchUp to deliver scaffolded, command-based activities with guided and collaborative practice. An embedded mixed-methods design with a one-group pretest–posttest structure was used with an intact class of 24 students over three weeks. The mean score increased from 12.88 (SD = 2.58) in the pretest to 16.79 (SD = 1.50) in the posttest, and all 24 students reached the passing standard in the posttest. A paired-sample t-test showed a statistically significant difference, $t(23) = 6.58$, $p < 0.001$, with a large effect size (Cohen's $d = 1.34$). Thematic analysis of post-intervention responses showed increased interest and engagement, reliance on teacher and peer guidance, skill development through practice and improved confidence, while a few students reported technical and equipment constraints. Because the pretest was a knowledge test and the posttest a performance task, the size of the gain is interpreted with caution. The systematic use of CADVENTURE, with targeted guidance, ample practice time, adequate digital resources and periodic evaluation, is recommended, and future studies should assess the long-term application of the acquired CAD skills with larger groups of participants.

Keywords: Computer-Aided Design, CADVENTURE, Digitalized Instructional Material, Action Research, TPACK Framework, Technical Skill Improvement, Technology and Livelihood Education

1. Introduction

Computer-Aided Design (CAD) plays an essential role in developing students' technical drawing and design skills, as it helps students visualize, modify and create precise designs. Many students, however, struggle to perform drafting tasks because of limited exposure, lack of guided instruction and minimal hands-on experience, since most of their learning focuses on theoretical discussion. As a result, many students find CAD very challenging.

CAD has become an important tool in technical education because it allows students to visualize, modify and create precise designs efficiently (Zira and Wilfred, 2019) [1]. In a CAD teaching context, Gracia-Ibáñez and Vergara (2016) found that reliance on traditional instruction and limited practical opportunities contributed to unsatisfactory student outcomes, and that an action research intervention including self-learning materials and more guided practice led to improved academic results [2]. This aligns with the problem identified among BTLEd-HE 2 students, which is a lack of guided instruction and insufficient hands-on activities in CAD. Atherton (1981) reported that many higher education programs using computer-aided design tools gave students more theoretical instruction than hands-on practice, which limited the students' ability to translate learning into applied skills [3]. This supports the observation that BTLEd-HE 2 students have limited opportunities to experience actual drafting design because of limited guided instruction and insufficient practical experience, and that an intervention emphasizing example-based practice and tool manipulation is needed. Students in CAD courses also reported better learning outcomes when direct, instructor-led practice was combined with hands-on activities rather than purely theoretical lectures (Dagman and Wärmefjord, 2022) [4].

The problem was observed among BTLEd-HE 2 students. A diagnostic test conducted by the researchers during problem identification showed that all students in the BTLEd-HE 2 section (100%) scored below the passing score. This result was further supported by an open-ended survey, in which most students stated that they struggled with CAD because of a lack of prior experience, guided instruction and hands-on practice. Classroom observations and consultation with the subject teacher confirmed that students performed CAD-related tasks slowly and had difficulty applying basic concepts. Overall, the data indicated the need for an intervention that provides structured guidance, practical exercises and engaging learning opportunities to strengthen students' CAD skills and experience.

This action research addresses the identified problem by developing and implementing an intervention within the researchers' scope of influence, rather than focusing on external constraints such as software limitations and computer laboratory resources in the Technology and Livelihood Education (TLE) program, which are beyond the immediate control of the teacher. The study emphasizes the enhancement of instructional strategies, interactive learning experiences and the integration of technology. Specifically, the study introduces "CADVENTURE: An Innovative Digitalized CAD Instructional Material", which integrates researcher-designed hands-on exercises, guided instruction and a final drafting task to strengthen learners' experience and confidence in performing CAD-related skills. Nurtanto et al. (2020) showed that interactive multimedia CAD lessons help students improve their understanding and performance [5]; CADVENTURE likewise uses interactive multimedia, such as visual tools, to make learning more engaging and effective.

1.1 Problem Statement

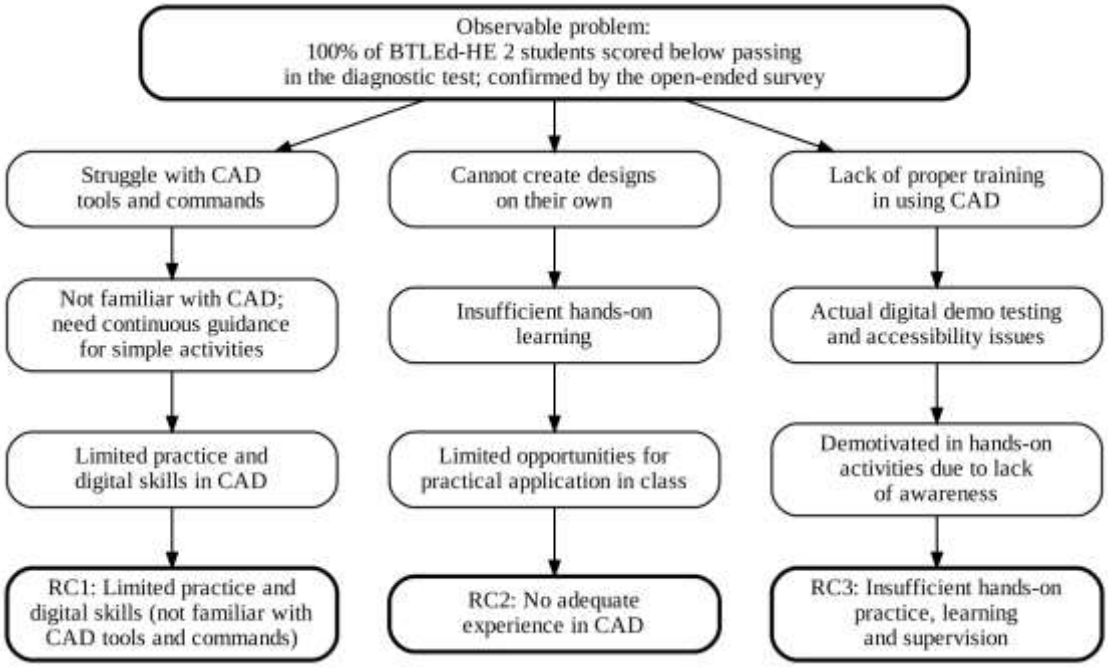
The BTLEd-HE 2 students who took BTLE 105: Introduction to ICT encountered significant challenges in understanding and applying Computer-Aided Design (CAD), which is covered under Course Learning Outcomes (CLO) 1 and 2 of the syllabus. In the diagnostic test, all students in the section scored below the passing rate, showing limited mastery of CAD-related concepts and skills. The open-ended survey revealed that almost all students had limited experience and minimal background knowledge of CAD, which resulted in difficulty recognizing CAD tools, manipulating basic commands and understanding how digital drafting works. Classroom observation and consultation with the subject teacher further showed that most students were not yet familiar with CAD and required continuous guidance to complete even simple activities.

The problem is described by several indicators: students have difficulty understanding and using CAD tools and commands, most cannot create drawings on their own, and they are not used to computer-based drafting. These challenges show a clear gap between theoretical understanding and practical application of CAD concepts. If the problem is not addressed, students may continue to experience low performance, reduced motivation and limited confidence in applying computer-based design skills. There is therefore a strong need for an intervention, through the CADVENTURE learning framework, that provides researcher-made exercises, guided practice and final drafting tasks designed to enhance students' engagement and confidence in using CAD.

1.2 Root Cause Analysis

To understand the reason behind students' difficulty with CAD, a root cause analysis was conducted using the Why-Why technique adapted from the action research process of the Department of Education (DepEd) Basic Education Sector Transformation (BEST) program. Through continuous questioning, consultation with students and teachers, and validation of evidence, the issue was traced from its observable symptoms to its fundamental causes. The causal chain is shown in Figure 1.

Figure 1: Why-Why Diagram Tracing the Causal Chain from the Observable Problem to the Root Causes



The analysis begins with the observable problem: all BTLEd-HE 2 students scored below passing in the diagnostic test, which was supported by their answers in the open-ended survey. This widespread symptom is the surface manifestation of deeper, interconnected issues within the learning environment. The immediate causes are threefold. First, students struggle with CAD tools and commands, indicating a fundamental barrier in using them. Second, they cannot create a design on their own, signifying difficulty in applying theoretical knowledge independently. Third, there is a lack of proper training in using CAD.

At the underlying level, the struggle with CAD tools and commands was traced to insufficient prior exposure and lack of familiarity, which results in limited practice and digital skills in CAD. The difficulty with independent design creation stems from insufficient hands-on learning, which provides limited opportunities for practical application. The lack of proper training is reinforced by issues in actual digital demonstration and accessibility, which contribute to students being demotivated in hands-on activities because of a lack of awareness. At the systemic level, students' unfamiliarity with CAD tools and their dependence on continuous guidance are linked to the limited availability of computers and software access in the TLE program, minimal exposure to real-world applications, insufficient interactive demonstration and reliance on theoretical discussion rather than experiential, technology-driven learning.

The analysis isolated three validated root causes that are within the instructional system's sphere of control and are therefore actionable through a targeted intervention:

1. Root Cause 1 (RC1): Limited practice and digital skills, as students are not familiar with CAD tools and commands. The lack of basic familiarity with interfaces and commands prevents students from connecting tool functions with practical drawing.
2. Root Cause 2 (RC2): No adequate experience in CAD. The lack of proficiency is attributed to the absence of sufficient, structured opportunities for students to engage in real CAD projects, without which procedural fluency and confidence in independent design work cannot develop.
3. Root Cause 3 (RC3): Insufficient hands-on practice, learning and supervision. The current practice structure, partly because of limited resources, does not provide enough continuous CAD application. Since the students are in Home Economics, a field in which CAD is not fully integrated, they miss chances for structured help in basic digital CAD work.

The root causes were validated against evidence and assessed for controllability, as summarized in Table 1. A fourth probable cause, the limited computer laboratory, was confirmed but is beyond the researchers' control and was therefore not targeted.

Table 1: Root Cause Validation Matrix

Probable Root Cause	Validation	Evidence Source	Controllability	Conclusion
RC1: Limited practice and digital skills	True	Diagnostic test, open-ended survey and teacher interview	Within control	Valid
RC2: No adequate experience in CAD (no proper training)	True	Diagnostic test, open-ended survey and teacher interview	Within control	Valid
RC3: Insufficient hands-on practice, learning and supervision	True	Diagnostic test, open-ended survey and teacher interview	Within control	Valid

Probable Root Cause	Validation	Evidence Source	Controllability	Conclusion
Limited computer laboratory	True	Inventory	Beyond control	Not targeted

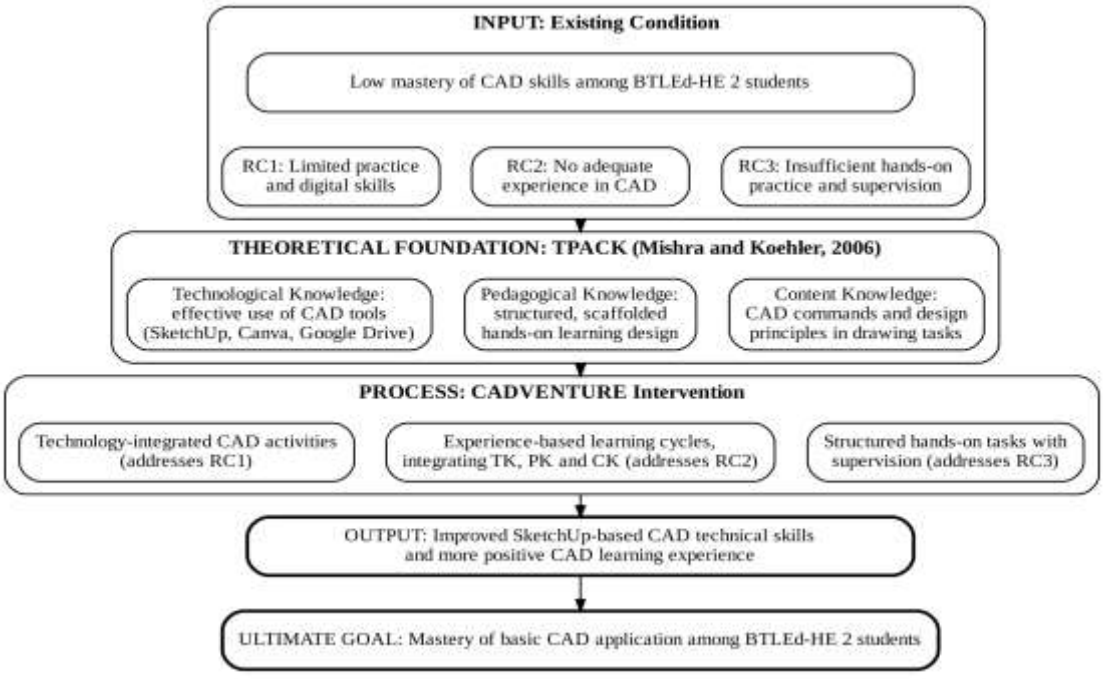
The root cause analysis therefore shows that students' low mastery is a direct outcome of conditions in the learning environment that the researchers can address, which provides a practical basis for designing the intervention.

1.3 Conceptual Framework

The conceptual framework is built on the Technological Pedagogical Content Knowledge (TPACK) framework (Mishra and Koehler, 2006), which explains effective technology-integrated teaching through the interaction of content knowledge, pedagogical knowledge and technological knowledge [6, 7]. In this study, students are expected to achieve technical mastery not through passive reception of information but through an active process in which the technology (CAD tools), the content (CAD commands and design principles) and the teaching methods are integrated in a hands-on learning context.

The input phase consists of the identified problem of low mastery of CAD skills and its three root causes. This context is examined through the TPACK framework, which informs the process phase, the design and implementation of CADVENTURE. The structured, hands-on learning tasks are grounded in Pedagogical Knowledge (PK) and address insufficient hands-on practice (RC3). The selection and use of appropriate CAD applications are guided by Technological Knowledge (TK) and address limited practice and digital skills (RC1). The purposeful integration of all three TPACK components through experience-based learning cycles ensures that students gain adequate experience in CAD (RC2). The expected outputs are improved technical CAD skills, meaning that students draw accurately and improve their basic manipulation in SketchUp, and a better learning experience, meaning that students are more engaged and develop a positive attitude towards learning CAD. The framework is shown in Figure 2.

Figure 2: Conceptual Framework of the Study



1.4 Research Questions and Hypothesis

The central question of this action research is: How does the implementation of the CADVENTURE intervention affect the mastery of SketchUp-based CAD application skills among BTLEd-HE 2 students? Specifically, the study sought to answer the following:

1. What is the level of SketchUp-based CAD technical skills of BTLEd-HE 2 students after the CADVENTURE intervention?
2. Is there a significant difference between the pretest and posttest scores of BTLEd-HE 2 students after utilizing CADVENTURE?
3. What is the overall effectiveness of the CADVENTURE intervention in achieving mastery of SketchUp-based CAD application skills among BTLEd-HE 2 students?

The null hypothesis tested at the 0.05 level of significance is: there is no significant difference between the pretest and posttest scores of BTLEd-HE 2 students after utilizing CADVENTURE.

1.5 Scope, Delimitation and Limitation

The study focused on enhancing the CAD skills and hands-on modeling competencies of second-year BTLEd-HE students of the TLE program of Davao Oriental State University in Academic Year 2025–2026 through the CADVENTURE intervention. The content was confined to scaffolded activities using SketchUp, Canva slides and Google Drive, guiding students from basic command learning to an integrated design output. Four activity outputs were completed and evaluated with rubrics, and the intervention was conducted over three weeks.

The study was delimited to the second-year BTLEd-HE students enrolled in BTLE 105: Introduction to ICT. CADVENTURE targeted CAD command mastery and basic technical drawing skills and did not cover advanced CAD topics beyond the scope of the course. It was confined to Canva, SketchUp and Google Drive and excluded other CAD platforms and offline exercises. The study measured skill improvement within the intervention period and did not evaluate long-term retention beyond the semester. Several factors may affect the results and their generalization. Students' prior experience with CAD tools and varying levels of digital literacy may have influenced their performance. Access to stable internet connections and functional devices was critical, and technical issues may have hindered learning. The three-week period may not be sufficient to achieve full mastery or long-term retention. The study involved only one class of BTLEd-HE second-year students and may not reflect the performance of students in other programs or institutions. The CADVENTURE activities were conducted as supplementary learning activities alongside the regular coursework and did not replace standard subject instruction.

1.6 Significance of the Study

For students, who are pre-service teachers, the study offers a way to enhance mastery of CAD commands and technical drawing skills, together with problem-solving ability, creativity in digital design, digital literacy and collaborative skills that transfer to other subjects. For teachers, it provides a replicable model, integrating Canva, SketchUp and Google Drive, for addressing learning gaps in CAD and ICT instruction within higher education TLE programs, as well as an example of classroom-based action research. For school administrators, it demonstrates a low-cost pathway for enhancing students' competencies without major facility upgrades. For future researchers, it serves as a reference that may be replicated, refined or expanded in other contexts. For the academic community, it contributes to knowledge on instructional innovation in higher education TLE programs, in line with the policies, standards and guidelines for the BTLEd program set by the Commission on Higher Education (CHED) in CHED Memorandum Order No. 78, Series of 2017 [8].

2. Methodology

2.1 Research Design

A classroom-based action research design was employed, which enables teacher-researchers to systematically examine their instructional practices, identify challenges and implement evidence-based strategies for improvement (Mertler and Hartley, 2017) [9]. The study used an embedded mixed-methods design, in which quantitative and qualitative data are collected and analyzed within a framework where one form of data supplements the other (George, 2025) [10]; this design allows the study to be understood as a whole (Sharma et al., 2023) [11]. In this study, quantitative data, which are numerical data collected and analyzed statistically, served as the main source of evidence, while qualitative data, which are non-numerical data such as text used to understand ideas, experiences and meanings, served to explain the quantitative results (Bhandari, 2020) [12]. The quantitative strand followed a one-group pretest–posttest structure.

The intervention followed a structured three-week process. In Week 1, students were oriented to CADVENTURE, took the pretest, participated in an open forum for clarification, explored SketchUp freely and began the first command-based activity. In Week 2, CAD commands were introduced through interactive Canva slides, followed by intensive hands-on practice in SketchUp. Week 3 was dedicated to the final output, in which all learned commands were integrated into a comprehensive design submitted through Google Drive.

2.2 Participants

The participants were a single, intact class of 24 second-year BTLEd-HE students (16 female, 66.67%; 8 male, 33.33%) enrolled in BTLE 105: Introduction to ICT, which includes a focus on CAD, at Davao Oriental State University during Academic Year 2025–2026. Purposive sampling was used, as this class was identified through the diagnostic test and the pre-intervention survey as having difficulties in CAD tool proficiency and technical drawing skills. All 24 students completed the intervention and were included in the analysis. The students' pretest and posttest scores, activity scores and task completion served as the primary sources of data.

2.3 Research Instruments

Two researcher-made instruments were used for the main quantitative analysis. The pretest was a 20-item multiple-choice test covering drafting standards, design principles and basic SketchUp tools. The posttest was the final activity, in which each student created a 3D house design in SketchUp. It was scored with an analytic rubric of four criteria (creativity and design, application of tools, detailing and realism, and overall presentation), each rated from 2 (poor) to 5 (excellent), for a total of 20 points. Activities 1 to 3 were scored with a four-criterion rubric (use of tools, following instructions, output presentation and file management) on the same 20-point scale and served as formative monitoring data, together with a progress tracking sheet on Google Drive and analysis of the completed CAD outputs.

The pretest questionnaire and all rubrics were developed by the researchers in alignment with the competency requirements of the BTLE 105 syllabus and were reviewed by three subject-matter experts, including a TLE master teacher of Davao Oriental State University, who evaluated the clarity, alignment and appropriateness of each item and criterion. The instruments were finalized based on the experts' feedback before use. Student outputs were then scored by the researchers using the validated rubrics.

Qualitative data were gathered after the posttest through open-ended survey questions and interviews about students' experiences and perceptions during the CADVENTURE activities.

2.4 Data Analysis

Pretest and posttest scores were analyzed using descriptive statistics (mean and standard deviation) to describe baseline and end-line performance. Since both instruments had a total of 20 points, scores were converted to percentages and interpreted using the scale of Munawaroh et al. (2022): 0%–20% = Very Poor, 21%–40% = Poor, 41%–60% = Moderate, 61%–80% = Good and 81%–100% = Very Good [13]. A passing criterion of 75% (15 of 20 points) was adopted in accordance with the institutional standard (DepEd, 2003) [14]. A paired-sample t-test at $\alpha = 0.05$ was used to determine whether the difference between pretest and posttest mean scores was statistically significant, using Microsoft Excel. Cohen's d for paired samples, computed as the mean gain divided by the standard deviation of the gain scores, was used to determine the practical significance of the change, so that the results reflect meaningful improvement and not only a statistical difference (Statsig Team, 2024) [15]. Following Cohen (1988), $d = 0.2$ indicates a small effect, $d = 0.5$ a medium effect and $d = 0.8$ a large effect [16]. Qualitative data were analyzed thematically through familiarization, initial coding, searching for themes, reviewing themes, defining themes and producing the report, an iterative process of data immersion, coding, categorization and theme development (Dahal, 2025) [17]. Table 2 shows how each research question was answered.

Table 2: Data Collection and Analysis Matrix

Research Question	Data Source	Instrument	Timeline	Analysis
1. Level of SketchUp-based CAD technical skills after the intervention	Posttest (final activity) scores	Final activity rubric	Week 3	Mean, standard deviation, percentage level and passing rate
2. Significant difference between pretest and posttest scores	Pretest and posttest scores	Pretest questionnaire and final activity rubric	Weeks 1 and 3	Paired-sample t-test ($\alpha = 0.05$)
3. Overall effectiveness of the intervention	Gain scores; open-ended survey and interview responses	Score records; survey and interview questions	Weeks 1 to 3; after the posttest	Cohen's d; thematic analysis

2.5 Procedure for Implementation and Monitoring

Before implementation, the performance assessment rubrics were given a final clarity and content check to ensure that they were appropriate for measuring beginner skill development, ethical approvals were secured, and all digital and physical materials, including the interactive slides and access to web-based SketchUp, were prepared. The implementation schedule is shown in Table 3.

Table 3: Implementation Timeline

Week	Date	Key Activities	Responsible Persons
Week 1	November 19, 2025	Orientation to CADVENTURE; pretest; checking of students' access to laptops, mouse devices and internet	Researchers and students

Week 1	November 21, 2025	Re-orientation; pretest for students absent on November 19; Activity 1 (Easy): drawing basic shapes in SketchUp	Researchers and students
Week 2	November 26, 2025	Activity 2 (Medium): creating basic 3D shapes	Researchers and students
Week 2	November 28, 2025	Activity 3 (Difficult): drawing a simple 3D house	Researchers and students
Week 3	December 1, 3 and 5, 2025	Final activity (posttest): student-designed 3D house; formative feedback; submission through Google Drive	Researchers and students

During the sessions, students who did not have laptops were allowed to use the researchers' laptops or shared laptops with classmates, and collaboration and peer support were encouraged. Slow internet connectivity during Activity 2 affected the pace of the session, and the researchers provided assistance and adjustments so that students could complete the task. The final activity was conducted over three sessions to give students sufficient time to conceptualize, design, revise and complete their outputs, while the researchers monitored progress, provided guidance, conducted formative assessment with the rubric and recorded observations of students' engagement, challenges and skill development.

2.6 Ethical Considerations and Risk Management

Informed consent was secured from the participants and all data were kept confidential. Student identities were replaced with codes (S1 to S24). Digital data were stored on a password-protected computer and physical documents were kept in a locked cabinet; all data will be destroyed five years after the completion of the study. A risk assessment, using likelihood and impact ratings from 1 to 4, identified four risks with preventive and contingency measures: failure of internet connectivity (score 16, extreme), addressed by pre-downloading slides, reserving an alternative room with a backup connection and extending or rescheduling sessions; time constraints during command practice (score 12, high), addressed by prioritizing five to six core commands, setting timed deadlines and peer tutoring; subjectivity in applying the rubric to creative outputs (score 9, high), addressed by standardizing the rubric interpretation with the resource teacher and using a second rater for random samples; and digital submission errors (score 6, moderate), addressed by clear file-format instructions, immediate verification and resubmission.

3. The CADVENTURE Intervention

CADVENTURE is a fully digitalized, hyperlinked, SketchUp-based CAD learning material designed to address the inadequate CAD skills and experience of BTLEd-HE 2 students. It integrates three digital platforms: instructional content, activities and step-by-step instructions are delivered through visual and easily navigable Canva slides; hands-on practice is done in web-based SketchUp, where students create technical designs and models; and outputs are submitted to Google Drive, which serves as a central repository. This workflow allows continuous monitoring, and the submitted outputs are evaluated with performance assessment rubrics.

3.1 Theoretical Underpinnings

The TPACK framework guided the design and implementation of the CADVENTURE activities by ensuring that the learning content (CAD commands), teaching strategies (hands-on, scaffolded practice) and technological tools (SketchUp, Canva and Google Drive) were meaningfully integrated [6, 7]. The intervention is also supported by the principle of formative assessment (Black and Wiliam, 1998), which

justifies the continuous use of performance assessment rubrics so that feedback is immediate and actionable [18].

3.2 Components and Pedagogical Features

The core component is a structured series of practical CAD manipulation activities organized into four progressive stages: Easy (Activity 1), Medium (Activity 2), Difficult (Activity 3) and the Final Output, which served as the posttest. All tasks are centered on CAD command manipulation in SketchUp. The pedagogical features are the following:

- Graduated difficulty: activities start with simple commands to build digital skills and progressively combine commands in hands-on practice.
- Final integration task: a comprehensive CAD activity requiring the integrated application of all learned commands and skills.
- Scaffolding, feedback and supervision: support materials, including video tutorials, and "just-in-time" support from the researcher-teachers, who offered personalized scaffolding for command manipulation and technical guidance.
- Collaborative learning: students explored tools, practiced designs and shared ideas together, receiving immediate feedback from peers, the researcher-teachers and the visual results in SketchUp.

Each component targets complementary domains of learning. Command-based learning activities primarily target the cognitive domain by enhancing understanding of CAD commands and procedures. Skill integration and application tasks primarily target the psychomotor domain by developing practical CAD skills. Final project development primarily targets the affective domain by fostering creativity, responsibility and self-directed learning. A typical session begins with a command-based activity, moves to an application task in SketchUp and ends with refinement of outputs for review, grading and feedback. Table 4 links each component to the root cause it addresses.

Table 4: CADVENTURE Intervention Component Matrix

Root Cause	Key Features	Implementation Process	Expected Outcome
RC1: Limited practice and digital skills	Step-by-step command tutorials through Canva slides; stepwise SketchUp exercises linked to theory	Daily guided sessions with teacher facilitation	Understanding and application of CAD commands
RC2: No adequate experience in CAD	Scaffolded task progression; realistic SketchUp modeling projects	Gradual release of responsibility; final project development	Enhanced hands-on modeling skills and accuracy
RC3: Insufficient hands-on practice, learning and supervision	Hands-on 3D manipulation activities; peer-assisted collaboration and feedback	Just-in-time teacher support; digital submission through Google Drive	Increased engagement, confidence and readiness for real-world CAD tasks

3.3 Implementation Framework and Resources

The intervention followed a three-week timeline (Table 3). Phase 1, introduction and exploration (Week 1), familiarized students with CADVENTURE, SketchUp (including account login and interface navigation), Canva slides and Google Drive. Phase 2, skill building (Weeks 1 and 2), carried out the command-based activities with continuous monitoring and supervised sessions. Phase 3, finalization (Week 3), was dedicated to completing the final outputs, which the researchers reviewed and graded using the rubrics. Implementation fidelity was monitored through protocol adherence checks, tracking of the completion of all four activities and observation of material and tool use, with weekly formative feedback. Human resources included the researchers as facilitators and evaluators, the school administration for scheduling and the participating students; material resources included SketchUp, Canva, Google Drive, step-by-step guides, computers and internet access in a TLE classroom. The total cost of Php 2,200.00 was covered by the researchers' fund: Php 500.00 for developing the materials, Php 500.00 for internet and data access, Php 200.00 for printing rubrics and documents, and Php 1,000.00 as a contingency fund.

4. Results and Discussion

The results are organized according to the research questions. Quantitative findings from the pretest and posttest are presented first, followed by the qualitative findings and their integration.

4.1 Level of CAD Technical Skills before and after the Intervention

Table 5 presents each student's pretest and posttest scores, their percentage equivalents, verbal descriptions, remarks based on the 75% passing standard and gain scores.

Table 5: Students' Pretest and Posttest Scores, Verbal Descriptions, Remarks and Gain Scores

Student	Pretest Score	Pretest %	Description	Remark	Posttest Score	Posttest %	Description	Remark	Gain
S1	15	75%	Good	Passed	16	80%	Good	Passed	1
S2	15	75%	Good	Passed	18	90%	Very Good	Passed	3
S3	13	65%	Good	Failed	16	80%	Good	Passed	3
S4	12	60%	Moderate	Failed	16	80%	Good	Passed	4
S5	15	75%	Good	Passed	19	95%	Very Good	Passed	4
S6	13	65%	Good	Failed	15	75%	Good	Passed	2
S7	14	70%	Good	Failed	16	80%	Good	Passed	2
S8	12	60%	Moderate	Failed	15	75%	Good	Passed	3
S9	14	70%	Good	Failed	17	85%	Very Good	Passed	3
S10	13	65%	Good	Failed	16	80%	Good	Passed	3
S11	5	25%	Poor	Failed	18	90%	Very Good	Passed	13
S12	14	70%	Good	Failed	15	75%	Good	Passed	1
S13	13	65%	Good	Failed	17	85%	Very Good	Passed	4
S14	14	70%	Good	Failed	15	75%	Good	Passed	1

Student	Pretest Score	Pretest %	Description	Remark	Posttest Score	Posttest %	Description	Remark	Gain
S15	11	55%	Moderate	Failed	16	80%	Good	Passed	5
S16	12	60%	Moderate	Failed	19	95%	Very Good	Passed	7
S17	12	60%	Moderate	Failed	18	90%	Very Good	Passed	6
S18	15	75%	Good	Passed	18	90%	Very Good	Passed	3
S19	19	95%	Very Good	Passed	20	100%	Very Good	Passed	1
S20	13	65%	Good	Failed	15	75%	Good	Passed	2
S21	11	55%	Moderate	Failed	17	85%	Very Good	Passed	6
S22	9	45%	Moderate	Failed	18	90%	Very Good	Passed	9
S23	14	70%	Good	Failed	15	75%	Good	Passed	1
S24	11	55%	Moderate	Failed	18	90%	Very Good	Passed	7

Note: N = 24; maximum score = 20. Passing = 75% (15 points) and above. Verbal description: 0%–20% = Very Poor, 21%–40% = Poor, 41%–60% = Moderate, 61%–80% = Good, 81%–100% = Very Good (Munawaroh et al., 2022) [13].

In the pretest, only five of the 24 students (20.83%) reached the passing score: S1, S2, S5 and S18 with 75%, and S19 with 95%. Ten students scored 65% to 70%, which is described as Good but is below the 75% passing standard; eight students scored 45% to 60% (Moderate); and one student scored 25% (Poor). Overall, 19 of 24 students (79.17%) did not pass the pretest, which justified the need for an instructional intervention.

In the posttest, all 24 students (100%) reached the passing standard. Twelve students scored 75% to 80% (Good) and twelve scored 85% to 100% (Very Good), with S19 obtaining a perfect score of 20. This answers the first research question: after the intervention, the students' SketchUp-based CAD technical skills were at the Good to Very Good level, with a mean of 16.79 (83.96%), and every student met the passing standard.

4.2 Difference between Pretest and Posttest Scores

Table 6: Descriptive Statistics and Paired-Sample t-Test Results

Statistic	Pretest	Posttest
Mean	12.88	16.79
Standard deviation	2.58	1.50
Variance	6.64	2.26
Observations	24	24
Pearson correlation	0.05	
Mean difference (posttest minus pretest)	3.92	
Standard deviation of differences	2.92	
95% confidence interval of the mean difference	2.68 to 5.15	

Statistic	Pretest	Posttest
Degrees of freedom	23	
t statistic	6.58	
p (two-tailed)	< 0.001 (0.000001)	
t critical (two-tailed, α = 0.05)	2.07	
Cohen's d (paired samples)	1.34 (large)	

The mean score increased from 12.88 in the pretest to 16.79 in the posttest, a mean gain of 3.92 points. The standard deviation decreased from 2.58 to 1.50 and the variance from 6.64 to 2.26, which indicates that the students' scores became more consistent after the intervention. The paired-sample t-test gave t(23) = 6.58 with a two-tailed p-value below 0.001. Since the computed t-value exceeds the two-tailed critical value of 2.07 and the p-value is less than 0.05, the null hypothesis is rejected: there is a significant difference between the pretest and posttest scores. This answers the second research question.

4.3 Overall Effectiveness of the Intervention

The effect size of the intervention, computed as Cohen's d for paired samples, was 1.34, which is a large effect according to Cohen (1988) [16]. At the individual level, all 24 students improved. Five students (S1, S12, S14, S19 and S23) gained one point, three students (S6, S7 and S20) gained two points, and the remaining 16 students (66.67%) gained three points or more. The largest gains were observed among students with the lowest pretest scores, such as S11 (5 to 18) and S22 (9 to 18), while S19, who already scored 19 in the pretest, reached the maximum score of 20.

The qualitative findings, drawn from a thematic analysis of students' open-ended survey responses and interviews after the posttest, are summarized in Table 7. Because a single response could be coded under more than one theme, the frequencies are not mutually exclusive and do not add up to 24.

Table 7: Themes from Students' Post-Intervention Responses

Theme	Frequency (n = 24)
Increased interest and engagement	24
Teacher and peer guidance as key support	23
Skill development through practice	21
Improved confidence in using SketchUp	20
Initial difficulty but gradual improvement	20
Creativity and design expression	15
Low or partial confidence due to technical challenges	6
Resource and equipment constraints	4
Independent and self-directed learning	4

All 24 students described increased interest and engagement. Many admitted having no initial interest, with one student noting, "At first, I find boring since I didn't know anything about CAD," but later found

it "very interesting" because it felt like a 3D game. Twenty students described the first encounter as "a bit confusing" or "really hard for me" but said it became "easier and easier" over time. Twenty-three students emphasized the step-by-step guidance of the teacher and peers, one explaining, "CADVENTURE was difficult if we weren't taught…it's easy for us now." This support improved confidence in using SketchUp for 20 students, who shared sentiments such as, "Now, I'm more confident using SketchUp because the ST's instruction was very clear," although six students still reported low or partial confidence because "there are really tools that are difficult." Skill development through practice was evident in 21 students, who noted that "doing that thing is a big help for us because…we can create a floor plan," while 15 students valued creativity and design expression, stating that they could "freely express my creativity not just in building projects like houses but also to showcase my talent." Four students mentioned resource or equipment constraints, such as working "without a mouse," and four demonstrated self-directed learning, one noting, "I actually explore it at home."

4.4 Integration of Quantitative and Qualitative Findings

The quantitative results show that CADVENTURE significantly improved students' CAD performance: the number of students meeting the 75% standard increased from 5 to 24, the mean score rose from 12.88 to 16.79, the variability of scores decreased, and the effect size was large. The qualitative findings help explain these results. Many students initially described CAD as difficult, confusing or intimidating, which is consistent with the low pretest performance. As the intervention progressed, students reported gradual improvement through guided instruction, repeated practice and hands-on activities, which is consistent with the increase in posttest scores. Increased interest and engagement, reported by all students, likely contributed to sustained practice. Teacher and peer guidance, identified by most students as a key support, helps explain the reduced variability of posttest scores, as consistent step-by-step instruction allowed students to progress at a similar pace. The theme of skill development through practice is consistent with the large gains of the 16 students who improved by three points or more. The small number of students who gained only one point is consistent with reports of technical challenges, partial confidence and lack of equipment, although two of these students (S1 and S19) already had passing pretest scores, so their small gains also reflect a high starting point.

4.5 Discussion

Bridging the gap between theoretical knowledge and practical proficiency in CAD is a significant challenge in technical education. This study found that students often fail to meet basic competency levels because of a lack of prior exposure to CAD applications and the absence of structured, accessible learning materials. A similar problem is described by Agadagba and Arubayi (2025), who report that even in a specialized field such as Home Economics, limited in-depth computer knowledge and insufficient ICT tools remain primary barriers to mastering CAD applications [19]. Gracia-Ibáñez and Vergara (2016) found that teaching that relies heavily on instructor-led lectures without sufficient practical reinforcement leads to unsatisfactory academic outcomes, a situation that mirrors the initial diagnostic results of this study [2].

To address these challenges, CADVENTURE was designed to provide an interactive learning environment with guided, self-paced practice. This approach aligns with the work of Nurtanto et al. (2020) on e-learning based AutoCAD 3D interactive multimedia in vocational education, which argues that, for technical skills to be transferred effectively, instructional materials should move from static text to interactive multimedia that integrates graphics, audio and step-by-step digital guidance, allowing students to navigate complex 3D modeling commands independently and turning learning from a passive

experience into an active, scaffolded one [5]. Together, the results of this study and the multimedia models in the literature suggest that digitalized instructional materials are not merely supplementary tools but essential interventions for turning inadequate skills into technical competence.

These findings should be interpreted with caution. The study used a single group without a comparison group, so improvement cannot be attributed to CADVENTURE alone, as regular coursework and practice effects may also have contributed. The pretest was a multiple-choice knowledge test, whereas the posttest was a rubric-scored performance task, so the two scores measure related but different aspects of CAD competence, and the gain partly reflects the difference between the instruments. In addition, the posttest rubric had a minimum possible score of 8 points, whereas the pretest could range from 0 to 20. The researchers who implemented the intervention also scored the outputs, and inter-rater agreement was not computed.

5. Conclusion

The implementation of CADVENTURE: An Innovative Digitalized CAD Instructional Material was an effective strategy for narrowing the technical skill gap among BTLEd-HE 2 students. The intervention addressed the root causes of low performance, namely limited practice and digital skills, inadequate CAD experience and insufficient supervised hands-on practice, by providing a structured, digitalized and command-based learning framework. All students reached the passing standard after the intervention, the mean score rose from 12.88 to 16.79 with a statistically significant difference and a large effect size, and performance became more consistent. The integration of the TPACK framework within CADVENTURE shows that combining targeted digital tools with scaffolded instructional support is important for developing basic CAD skills in technical education.

5.1 Theoretical Implication

This study shows how the TPACK framework can be put into practice to address skill gaps among non-engineering majors such as Home Economics students. For students with limited digital skills and insufficient prior exposure, Technological Knowledge was applied through accessible, hyperlinked platforms such as SketchUp and Canva to lower entry barriers; this technology was integrated with Pedagogical Knowledge through a scaffolded, game-like instructional design providing the hands-on supervision and step-by-step guidance missing in traditional lectures; and core design principles (Content Knowledge) were embedded directly in the interactive tasks. The results support the view that the alignment of technology, pedagogy and content helps students move from initial difficulty to technical competence.

5.2 Sustainability and Action Plan

To sustain the effectiveness of CADVENTURE, continuous monitoring and evaluation of students' progress will be implemented, and strategies will be adjusted to address recurring challenges such as poor or intermittent internet access, problems with students' devices and differences in students' pace, since some students need more time and one-on-one guidance. Flexible learning periods, optional tutorial sessions and consistent follow-up will be provided. For the next batch of students, all materials, procedures and tools developed in this study will be organized, refined and shared with instructors, orientation sessions will be conducted so that teacher-educators can apply the intervention consistently, and each implementation will include scheduled monitoring, additional tutorial sessions and periodic evaluation of effectiveness.

5.3 Reflection and Recommendations

While the quantitative results showed a clear improvement in overall performance, it was also observed that some students readily absorbed the material while others required considerably more time. These differences show that teaching a technical subject such as CAD must be flexible and ready to provide personalized, one-on-one help. The following are therefore recommended. First, instructors should sustain and prioritize targeted, individualized support for struggling learners. Second, additional time and instructional resources, such as scheduled open laboratory sessions, should be allocated for students who need extra practice. Third, future implementations should include regular evaluations to detect new problems, such as technology issues, so that strategies can be adjusted promptly. Finally, future studies should use the same type of instrument for the pretest and posttest, include a comparison group, compute inter-rater reliability, and assess the long-term application of the acquired CAD skills with larger groups of participants.

Acknowledgement

The researchers express their sincere gratitude to Dr. Maria Gloria R. Lugo, research adviser, for her guidance, patience and insights; to the research panelists, Ms. Cheramie M. Ambayec, Ms. Cherilyn V. Malintad, Mr. Guillermo L. Bello Jr. and Mr. James Roland V. Galvez, for their expertise and critical reviews; to the instrument validators for their time and valuable suggestions; to the participating students for their cooperation; to their families and friends for their support; and, above all, to the Almighty God for the wisdom and strength that made this research possible.

References

1. Z. Zira, S. Wilfred, “Impact of AutoCAD Application Instruction on Students’ Academic Performance and Motivation in Building/Engineering Drawing in Technical Colleges of Adamawa State, Nigeria”, International Journal of Research and Innovation in Applied Science, August 2019, 4 (8), 25–30. https://rsisinternational.org/journals/ijrias/DigitalLibrary/Vol.4&Issue8/25-30.pdf
2. V. Gracia-Ibáñez, M. Vergara, “Applying Action Research in CAD Teaching to Improve the Learning Experience and Academic Level”, International Journal of Educational Technology in Higher Education, 2016, 13, Article 9. https://doi.org/10.1186/s41239-016-0010-5
3. D. Atherton, “The Role of CAD in Education and Research”, IFAC Proceedings Volumes, 1981. https://www.sciencedirect.com/science/article/pii/S1474667017639752
4. A. Dagman, K. Wärmefjord, “An Evidence-Based Study on Teaching Computer Aided Design in Higher Education during the COVID-19 Pandemic”, Education Sciences, January 2022, 12 (1), Article 29. https://doi.org/10.3390/educsci12010029
5. M. Nurtanto, H. Sofyan, P. Pardjono, “E-Learning Based AutoCAD 3D Interactive Multimedia on Vocational Education (VE) Learning”, Journal of Engineering Education Transformations, July 2020, 34 (1), 21–27. https://doi.org/10.16920/jeet/2020/v34i1/147793
6. P. Mishra, M.J. Koehler, “Technological Pedagogical Content Knowledge: A Framework for Teacher Knowledge”, Teachers College Record, 2006, 108 (6), 1017–1054.
7. S. Kurt, “TPACK: Technological Pedagogical Content Knowledge Framework”, Educational Technology, May 2018. https://educationaltechnology.net/technological-pedagogical-content-knowledge-tpack-framework/

8. Commission on Higher Education, "Policies, Standards and Guidelines for the Bachelor of Technology and Livelihood Education (BTLEd)", CHED Memorandum Order No. 78, Series of 2017.
9. C. Mertler, A. Hartley, "Classroom-Based, Teacher-Led Action Research as a Process for Enhancing Teaching and Learning", Journal of Educational Leadership in Action, 2017, 4 (2), Article 3. https://doi.org/10.62608/2164-1102.1056
10. T. George, "Mixed Methods Research: Definition, Guide & Examples", Scribbr, January 14, 2025. https://www.scribbr.com/methodology/mixed-methods-research/
11. L.R. Sharma, S. Bidari, D. Bidari, S. Neupane, R. Sapkota, "Exploring the Mixed Methods Research Design: Types, Purposes, Strengths, Challenges, and Criticisms", Global Academic Journal of Linguistics and Literature, January 2023, 5 (1). https://doi.org/10.36348/gajll.2023.v05i01.002
12. P. Bhandari, "What Is Quantitative Research? Definition and Methods", Scribbr, June 2020. https://www.scribbr.com/methodology/quantitative-research/
13. Munawaroh, N.S. Setyani, L. Susilowati, "The Development of Electronic Problem Based Learning (E-PBL) Method in Entrepreneurship Course", Atlantis Press, November 2022. https://doi.org/10.2991/978-2-494069-15-2_15
14. Department of Education, "Assessment and Evaluation of Learning and Reporting of Students' Progress in Public Elementary and Secondary Schools", October 10, 2003. https://elibrary.judiciary.gov.ph/thebookshelf/showdocs/11/45138
15. Statsig Team, "5 Things to Understand about Statistical Significance", Statsig, July 2024. https://www.statsig.com/perspectives/things-to-understand-about-statistical-significance
16. J. Cohen, Statistical Power Analysis for the Behavioral Sciences, 2nd Edition, Lawrence Erlbaum Associates, 1988.
17. N. Dahal, "Qualitative Data Analysis: Reflections, Procedures, and Some Points for Consideration", Frontiers in Research Metrics and Analytics, September 2025. https://doi.org/10.3389/frma.2025.1669578
18. P. Black, D. Wiliam, "Assessment and Classroom Learning", Assessment in Education: Principles, Policy and Practice, 1998, 5 (1), 7–74.
19. L.A. Agadagba, D.O. Arubayi, "Challenges Facing the Use of Computer-Aided Design in Teaching Garment Pattern Making in Colleges of Education in Delta State", June 2025. https://www.researchgate.net/publication/392193505_Challenges_Facing_the_Use_of_Computer-Aided_Design_in_Teaching_Garment_Pattern_Making_in_Colleges_of_Education_in_Delta_State