SCIENTIFIC CULTURE
www.sci-cult.com

SCIENTIFIC CULTURE, Vol. 12, No. 2.1, (2026), pp. 7222-7235
Open Access. Online & Print

DOI: 10.5281/zenodo.19671506

EVALUATING THE PEDAGOGICAL IMPACT OF COMPUTER-AIDED DESIGN VERSUS MANUAL DRAFTING ON PERFORMANCE, EFFICIENCY, AND LEARNING OUTCOMES IN INTERIOR DESIGN WORKING DRAWINGS

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Received: 20/02/2026
Accepted: 31/03/2026

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ABSTRACT

The present study examines performance and preference in interior design students to use computer-aided design (CAD) rather than hand drafting in working drawings coursework, including assignments, terms, and exams. Advanced technical representations in architectural education, like working drawings, require precision, spatial reasoning, and communication. A structured questionnaire was designed based on a pilot study that involved focus groups at the design and applied arts department of Yarmouk University, Jordan, which were given to 21 educators and 59 students. Experimental tasks with 28 third -year-old students revealed that cad considerably decreased the time of the task completion (m = 32.32 min, sd = 9.96) in comparison with the traditional method of manual drafting (m = 52.36 min, sd = 9.48; t = -7.709, p = 0.001) with no severe differences in the overall performance of cad across all the quality dimensions, such as the design solution, the formal and spatial principles, design process, and the survey responses showed a high amount of people using cad because it is efficient, clean, and easy to make amends, but respondents stated that the overuse of cad as copy commands can hamper conceptual comprehension. Participants used hand drafting as their favorite in the process of note-taking on site visits. The findings indicate that a hybrid pedagogical style incorporating CAD to provide efficiency and manual drafting to provide cognitive reinforcement is the best strategy for improving the learning process and performance of workflow in working drawings courses.

KEYWORDS: Computer-Aided Design (CAD), Manual Drafting, Interior Design Education, Working Drawings, Design Performance Assessment, Spatial Cognition, Drafting Efficiency, Hybrid Pedagogical Approach.

1. INTRODUCTION

The speed at which the built environment professional fields have been digitalized has essentially altered the knowledge foundation of architectural and interior design education, specifically in the area of technical representation and working drawings. Over three decades, computer-aided design (cad) systems have increasingly displaced or augmented manual drafting practise in response to growing requirements of increased accuracy, speed, standardisation, and professionalism (Pektaş & Erkip 2006, 79; Ozkan & Yildirim 2016, 242). Working drawings as an important element of design communication with forms of significant communicative quantity are a technologically advanced phase of the design education process that involves precision, coordination, and communication (Fakery, Kamel, and Abdelaal 2021, 3334). Although the use of CAD tools is ubiquitous in modern practise, the educational effects of digital drafting taking the previous methods remain controversial in the academic discussion (Goldschmidt 2017, 79). The issue has been that scholars have suggested that drawing is not a representational action but a cognitive process that mediates the spatial thinking, problem-solving, and design thinking (Bayrakdarian, 2017). In turn, the shift towards the CAD-based workflow and the rejection of hand drafting bring some basic concerns about the learning outcomes, skills acquisition, and comprehension of concepts. This conflict can be traced, specifically in interior design education, where learning aims are the spatial detailing, material articulation, and dimensional accuracy (Açici & Sönme 2014,718). The continued existence of manual drawing in the teaching of design in the early years of design technology in design education, as well as in the teaching of higher-level courses in CAD, raises the issue of a gap in debate about the role of each of these methods in education. Consequently, the data of the practical and pedagogical efficiency of CAD and manual drawing in the working drawings coursework is an urgent and appropriate question. This paper is a reaction to this necessity by providing an empirical assessment of drafting strategies in situational controlled learning. In this way, it will help to expand an already existing literature on the need to gather evidence-based integration of digital and manual tools in design education.

Manual drafting has historically been considered as being the basis of architectural and interior design education, developing hand and spatial cognition and a discipline of method (Yildirim and Kasal 2005, 291). The components of manual drawing processes can help students learn scale, proportion, and construction logic because they interact directly with drawing tools (Goldschmidt 84). A number of studies underline the fact that freehand and technical hand drawing support reflects reflective thinking and iterative problem framing through the design process (Mohamed 2014, 5052). Nevertheless, the growing sophistication of modern design projects has made manual drafting an inadequate technique on its own, especially when it comes to multidimensional coordination and workflows marked by revision (Ibrahim and Rahimi a 2010, 982). By comparison, cad systems were known to provide the precision of calculation, quick adaptation and standardised records and they were well fitting the needs of the professional practise (Ozkan and Yildirim 2005, 243). Studies have proved that the use of CAD saves lots of time used in drafting the work and does not lower or worsen the quality of work (Fakhry et al. 2021, 3336). Still, there is a concern about excessive dependence on digital automation, in particular, copy and modification statements, which can decrease the cognitive ability of students to conceptually engage with drawing conventions (Akah, Bassey, and Ukpong 2021 167). This has been increased in learning institutions where students use the tools of cad technology before they develop the basics of drafting (lee). Consequently, the education world is still split over whether CAD will improve or undermine learning in technical drawing courses. It is these very unresolved tensions that highlight the need for systematic, empirical comparisons which should be based on measures of educational performance.

Recent research has opened up to broaden the debate by studying creativity, flow experience, and digital cognition in a CAD-mediated design setting. According to Dawoud, al- Samarraie and Zaqout (2015,546), creative behaviour may be promoted with the help of CAD tools when a state of cognitive flow is reached by the students. They however, warn that over complexity of the interface can be a retardant to beginner learners. Coşkun, gur, and Toğay (2018, 201–202) discovered that hand sketching was better in the initial stages of ideation when compared to cad, whereas cad was beneficial in refining and presentation phases. These results support the idea that various instruments assist various cognitive processes in designing. Further complex analysis of creative technologies in architectural design also highlights the fact that the tools should be used in harmonising the pedagogic goals and the technological tendencies, not only based on them (fang et al. 2025). However, creativity-oriented literature tends to abuse technical draught accuracy and technical documentation that is mandatory in working drawings. This omission is imperative, where working drawings take the precept of accuracy and conformity over idea play. Hence, the knowledge gained in the field of creativity should be utilised in terms of technical coursework demands. This gap has continued to be a challenge to design educators. The current research provides a solution to this issue by putting the issues concerning creativity in a technically sound assessment framework.

On the institutional level, cad was integrated into design curricula based on the technological availability, faculty skills, and accreditation requirements. Vazquez points to the wide range of variability in cad teaching in European architecture schools, and that there is not a lot of agreement on the pedagogical sequence. Like obstacles have been reported in evolving education systems, in which infrastructure limitations, as well as training limitations, impede successful cad implementation (Maina 2014). Digital transformation efforts in the higher education sector have fast-tracked the cad integration process in Jordan, although pedagogical harmonisation is ongoing (Al Shafei et al. 2025). These problems in the systems tend to lead to disjointed learning experiences in the sense that students become proficient in software development with minimal conceptual knowledge on how to draught logic. The literature of architectural software trends underlines increased discontent between educational education and professional practise demands (Shkliar et al. 2024, 463). Due to the emerging trend of increased industry needs of Bim-qualified graduates, basic drafting skills may become marginal. This tension indicates that it is necessary to systematically assess educational results and not to believe that technology is better. Curriculum changes, unless evaluated, can lead to a negative effect on learning. Thus, context-driven pedagogies require localised empirical research to guide the contextual use of pedagogy. The present study provides this evidence in the context of the Jordanian interior design education.

Although the current literature is extensive, there are still a few gaps that are critical to fill. First, it has very little experimental data on a direct comparison of cad and manual drafting in the area of working drawings related to interior design. Second, few studies use standardised assessment rubrics that assess on various aspects of design performance such as quality of solution, spatial logic, process and communication. Third, limited data are observed during the process of complete execution of the task, which generally restricts the understanding of the challenges and practical strategies of students in the real-time. Fourth, timing efficiency is frequently described, as opposed to being tested statistically about its significance. Lastly, most research uses either perception or final outputs of students without the embracement of two or more data sets. All of these imply that there is a low generalizability and pedagogical applicability of currently available findings. To solve them, an experimental approach should be developed with a combination of both quantitative and qualitative tools. This may offer a better idea about the impacts of drafting techniques on the learning outcomes. The current paper is specifically meant to address these gaps. It takes an experimental but controlled design in line with interior design education.

This current study is based on the earlier studies conducted so far since it applies the logical experimental design method into a group of interior design students who have been exposed to both forms of drafting previously. In contrast to surveys based on perception, this one considers actual performance by the students through a standardised rubric comprising of design solution, spatial principles, design process, and communication. The time efficiency is quantitatively analysed and measured statistically, which is a limitation of the previous studies. Data gathered through observations in the process of performing the tasks further contribute to the analysis by understanding the difficulties in the processes and difficulties with the tools. The study achieves a better ecological validity through placing the experiment in the context of a real coursework. Furthermore, the emphasis on interior design, as opposed to architecture is something that helps expand the scope of study of the current research. The combination of both manual and cad tasks is also a guarantee of an unbiased comparison devoid of task bias. Independent-sample t-tests are statistically powerful tests to give evidence on the differences in performance. This rigour of methodology sets the study apart to most of the available literature. As a result, the results provide a valid foundation of pedagogical suggestions.

2. METHODOLOGY

In this section, the methodology will be mentioned, which will be adhered to in order to achieve the objectives of the study, and make the final results credible. all the procedures followed will be described in the next paragraphs, beginning with the study design and its instruments, the choice of a sample, the ways, in which data were collected and analysed, and the examination of scientific considerations in this study.

2.1. Study Design

The interior design group was picked with the help of purposive sampling to include 28 students of the third-year level to take part in the focus group. Purposive sampling is a non-probability sampling method, in which subjects are selected according to particular criteria to make sure that valuable and useful information is availed to fulfil the intended goals of the study (Campbell, 2020). They were randomly chosen, and the respondents were all experienced in the manual and cad approach to drafting. The inclusion criteria were determined by the students who had prior experience in the practise of interior design during their studies, these students underwent the space planning and lighting course, where eight pre-course work courses were mandatory before admission. The discussion was free of charge. As described by Redmond and Curtis (2009), focus group sample size is established depending on topic of debate, level of knowledge of the same and whether group supervisor would handle it effectively. Morgan (1998) proposed a range of 10-12 participants, whereas Krüger and Casey (2000) mentioned the number of 6-8 participants, particularly when dealing with complicated issues that the supervisor can conduct the group and give the participants a chance to define their perspectives and ideas. According to the above, it was determined that the sample of this study (ten participants) is a befitting sample to get in-depth information regarding the causes of stress among students.

2.2. Participants

A sample of 28 third-year interior design students of the Yarmouk university in Jordan was used in this study. The sample was chosen randomly, and all the participants had worked in the mode of manual drafting and in cad drafting. These students were taking the space planning and lighting course which had a pre-requisite of eight courses. Every participant was provided with a five-grade bonus during the same course as a reward of his or her voluntary participation in the study. This experiment was conducted in a normal class period following mid-term exams. In order to determine the difference between the two approaches in order to measure it, we directed the students to undergo a task with the help of manual drafting on one day of the week and cad drafting on another day of the week. We engaged the students to repeat the task in order to provide the same assessment of the two methods.

2.3. Materials

The students were provided with a floor plan of a master bedroom with a table illustrating the necessary furniture inside the plan and provided dimension of the plan and the furniture. Manual experiment, provided with paper: in the manual procedure the students were provided with a printed plan outline which was placed on a4 paper as indicated in figure 1 and provided with a ruler which taken the form of a furniture template.

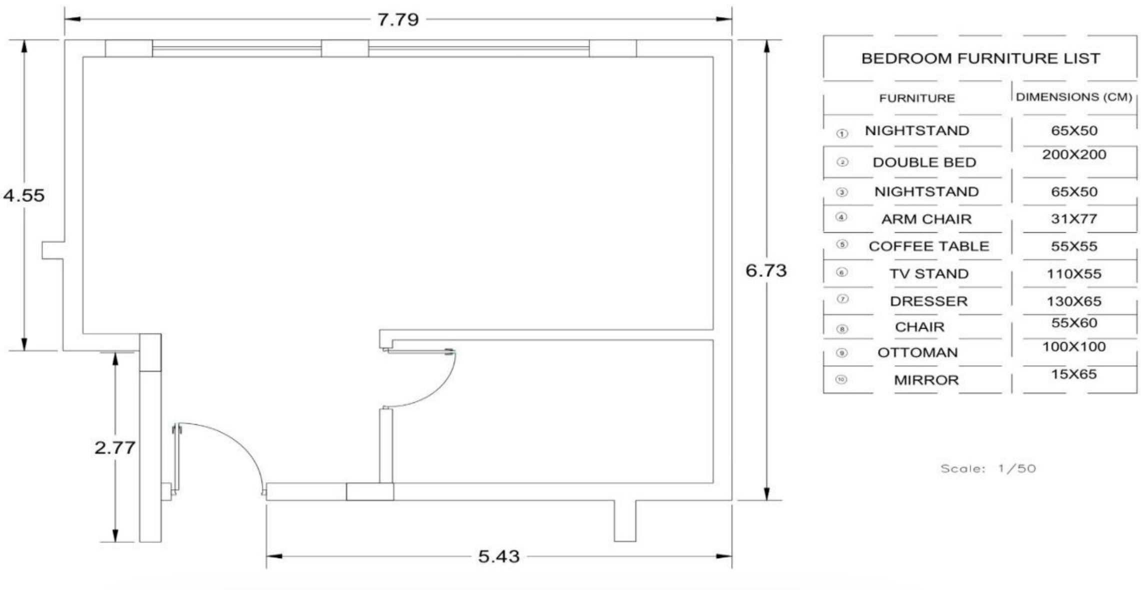


Fig 1: Manual Experiment Given Paper.

2.4. Procedure

The participants were informed that their work will be used as research subjects, and they will be assured of confidentiality before the experiment commenced. They were further promised that the five-grade incentive they will get would be a result of the participation and not the quality of their work. The time allowed to complete each task was 60 minutes and the researchers monitored and documented progress of the students after every 20 minutes, 40 minutes, and after 60 minutes. In all the tasks, the researchers made critical observations, such as difficulties experienced by the students, especially in the cad software. The work conducted by the students after the completion was marked with the help of a standardised rubric in which four categories were considered: design solution (40%), formal and spatial principles (20%), design process (20%), and communication (20%). These items had a 5-point item scale with a range of inadequate (1) to mastery (5). Also, the time required to undertake the task was time-stamped to determine the effectiveness of each approach.

2.5. Data Collection and Analysis.

The obtained data were assessed with the help of descriptive statistics to compare the performance of students in the four evaluation categories that introduce manual and cad drafting of the students. Mean score and standard deviation of each category were taken, and independent-sample t-test was employed to find out how many important differences were between the two approaches. When it came to timing, cad drafting took a much shorter time, and on average, the participants took less time (m = 32.32 minutes, sd = 9.96) than with manual drafting (m = 52.36 minutes, sd = 9.48). Nonetheless, regarding design quality, which comprised of design solution, formal and spatial principles, design process, and communication, there was no significant difference between the two approaches, which showed similarities in the approach of the two methods.

3. RESULT AND DISCUSSIONS

3.1. Results

To provide greater clarity and rigour in the analysis, the research findings are explained through three successive layers of analysis. First, it reports descriptive statistics of computer-created designs, including measures of central tendency and dispersion of all the performance dimensions and timing.

Second, the descriptive statistics of manually created designs are represented with the help of the same statistical parameters which can be analysed in parallel. Third, the test of the difference between the two drafting methods is done by means of an independent-sample t-test that will show whether the observed differences are statistically relevant.

3.2. Overall Performance Outcomes of Computer-Created Designs

Descriptive statistics on the performance results of computer-generated designs were compared to create a reference point of student achievement in the cad condition. Out of a total group of 28 interior design students (n = 28), a task involving the working drawing was performed through the application of cad tools, their results were scored according to four established performance dimensions in addition to performance and time span it took to complete the task. Each variable was also computed on the measures of central tendency and dispersion, such as mean, standard deviation, median, and range. These measures give a holistic picture of performance division without creating the impression of causality or comparative advantage. Each of the values provided in this section represents absolute results of the cad condition alone. All the descriptive statistics can be seen in table 1.

With respect to design quality, the mean score for the design solution (40%) dimension was 26.25 (sd = 7.06), with a median of 29.00 and scores ranging from 10 to 35. The formal and spatial principles (20%) dimension yielded a mean of 12.96 (sd = 3.37), a median score of 14.00, and a range between 4 and 17. For the design process (20%) dimension, the mean score was 12.61 (sd = 3.75), with a median of 14.00 and a range from 3 to 17.

The communication (20%) dimension recorded a mean score of 12.50 (sd = 3.74), a median of 14.00, and values ranging between 3 and 17. These results document the spread and central tendency of performance across all rubric components for cad-generated drawings.

No further aggregation or comparison is applied at this stage.

The overall average performance score for computer-created designs was 64.32% (sd = 17.46), with a median value of 69.50% and a range extending from 24% to 85%.

In terms of efficiency, the task completion time for cad drafting averaged 32.32 minutes (sd = 9.96). The median completion time was 33.00 minutes, with observed durations ranging from 14 to 60 minutes. All timing data were recorded under identical task constraints and measurement conditions. Together, these statistics provide a complete quantitative profile of performance and efficiency under the cad condition. No inferential analysis is introduced in this section.

Table 1: Descriptive Statistics for Performance Variables in Computer-Created Designs (N = 28).

Variable	Mean ± sd	Median	Range
Design solution (40%)	26.25 ± 7.06	29.00	10–35
Formal & spatial principles (20%)	12.96 ± 3.37	14.00	4–17
Design process (20%)	12.61 ± 3.75	14.00	3–17
Communication (20%)	12.50 ± 3.74	14.00	3–17
Overall average (%)	64.32 ± 17.46	69.50	24–85
Timing (min)	32.32 ± 9.96	33.00	14–60

The variation of scores in all the dimensions of performance in computer created designs denotes that there is a certain degree of variation between participants. The standard deviation figures came by values of 3.37 to 7.06 across the four elements of the rubric, which is composed of differences between the individual execution of the same digital drafting setting. The median scores of all the four dimensions were always higher or equal to the corresponding means indicating that scores were clustered towards the upper points of each of the scales. The score ranges observed indicate that on one hand, there are individuals who had almost maximum scores in several dimensions, but on the other hand, there are low levels of performance under the cad condition. This distribution establishes that the cad-based work does not result in homogenous work but differentiated work is produced. This kind of differentiation is crucial to the validation of sensitivity of the assessment rubric applied in the experiment.

In the case of efficiency, the time data about all computer-generated designs record a broad range of time taken to complete a task, between 14 and 60 minutes of time although the tasks need the same requirements and the same time availability. The mean difference of 9.96 minutes shows that there is significant variation in the drafting speed among the participants. The fact that the mean completion time (32.32 minutes) is relatively close to the median (33.00 minutes) happens to show that the timing data are more or less symmetrical. All of these values record the nature of operation of cad drafting in controlled academic environments. The efficiency data was reported by all participants and any timing measurement was consistent among them, and therefore reliable. These findings in combination with the performance statistics give us a quantitative baseline of computer-created working drawings in their entirety.

3.3. Overall Performance Outcomes of Manually - Created Designs

Descriptive statistical analysis was used to record the performance results of manually designed designs which were considered in order to document student success at the manual drafting condition. A total of 28 interior design students (n = 28) were given the working drawing task to be complete using the traditional hand drafting tools, and results were evaluated using the common standardised rubric used in all the experimental conditions. The performance was rated at four preset dimensions, namely design solution, formal and spatial principles, design process and communication as well as the total average performance and time taken to complete a task. Each variable had its measures of central tendency and variability (mean, standard deviation, median, and range). The section only provides absolute manual drafting performance outcomes. None of the values is shown through inference or comparison.

Regarding design quality, design solution (40%) dimension achieved a mean score of 25.39 (sd = 6.10), a median of 25.00, a range of 16 to 37. The spread is moderate around the central tendency, as the median is quite close to the mean, and the score dispersion is balanced. The formal and spatial principles (20%) dimension had a mean score of 13.61 (sd = 2.99) and a median of 13.50 with a range of 8 through to 18. These statistics represent quantifiable variability in spatial articulation and proportional control in the operations of the manual draughts. The standard deviation is relatively small, indicating that the performance of the participants in the area in terms of spatial reasoning is consistent. The values are all the results of tasks that were completed with the same set of constraints.

The design process (20%) dimension provided a mean score of 13.04 (sd = 3.26), the median score was 12.00 and the range of scores ranged between 5 and 18. The identified range demonstrates that there is a potential procedural execution and workflow development among participants. These values give us an indication of a slightly right skewness of distribution since the difference between the mean and the median indicates that the distribution is skewed towards the right and some of the better performing output extends the upper values. In relation to the communication (20%) dimension, the average score was 12.86 (sd = 3.44), a median of 12.00 and 5-18. The findings record inconsistency in the clarity, legibility, and the technical notation in manually drawn drawing. At this point, there is no accumulation of measures to the reported levels.

The total mean design performance score of manually-created designs was 64.89 (sd = 14.67), median = 63.50, and the minimum and maximum observed score of 37 and 91, respectively. The close similarity of the mean and median shows that the distribution of overall performance scores is relatively balanced. Standard deviation indicates medium variation in the aggregate performance among participants. Such values provide a summary of cumulative performance within each of four dimensions of performance. All the calculations were based on the standardised rubric scores. The average as a whole is a sum total of a measure of the manual drafting performance during the experimental conditions.

Efficiency on average it took 52.36 minutes (sd = 9.48) to complete a design created manually. They took an average of 55.50 minutes to complete a task, and a range of 20 and 60 minutes was observed. The ranging value of the timing values depicts a lack of uniformity of drafting speed between the participants when they utilise manual tools. The gap between the means and median indicates a left-skewed distribution with a slight skew which indicates a group of quicker completion of the tasks. Timing measurements were made at all times during initiation to submission of task. These statistics record in full the time of execution when the manual drafting condition is applied.

In order to further explain the internal structure of manual drafting performance, the descriptive statistics of the tables 2 and 3 are in both the comprehensive and dimension- grouped format. Such a two-fold presentation contributes to the transparency and makes the latter analysis easier without delivering redundancy. There were no data transformation and normalisation, except for descriptive summarization. The

tables store all statistical values that are needed manually accurately as they were before. This stratified presentation makes it complete and structurally consistent with the previous results sections.

Table 2: Descriptive Statistics for Performance Variables in Manually-Created Designs (N = 28).

Variable	Mean ± sd	Median	Range
Design solution (40%)	25.39 ± 6.10	25.00	16–37
Formal & spatial principles (20%)	13.61 ± 2.99	13.50	8–18
Design process (20%)	13.04 ± 3.26	12.00	5–18
Communication (20%)	12.86 ± 3.44	12.00	5–18
Overall average (%)	64.89 ± 14.67	63.50	37–91
Timing (min)	52.36 ± 9.48	55.50	20–60

Table 3: Distribution Characteristics of Manual Drafting Performance Variables.

Performance category	Central tendency indicator	Variability indicator
Design solution	Mean ≈ median	Moderate sd (6.10)
Formal & spatial principles	Mean ≈ median	Lower sd (2.99)
Design process	Mean > median	Moderate sd (3.26)
Communication	Mean > median	Moderate sd (3.44)
Overall average	Mean ≈ median	Moderate sd (14.67)
Timing	Median > mean	Sd = 9.48

The summary of the scores in the four dimensions of performance in the designs that are created manually implies the quantifiable changes in the student results in the case of the manual drafting. The standard deviation was between 2.99 and 6.10 which implied that the degree of consistency varied across the measured dimensions. Design solution, formal and spatial principles, design process and communication median values put forward closely similar figures to the respective mean scores, and the central tendencies appear to be relatively stable. The ranges observed prove that there are other participants with high scores that are close to the upper bounds of each dimension, although there were low scores as well that help to increase the overall dispersion. This spread proves that the assessment rubric was sensitive to the differences in the performance during the manual drafting. Any reported distributions are the results of doing the same task with the same requirements and an evaluation standard.

Concerning efficiency, the timing data of manually designed designs indicates that the distribution of the time that it takes to do some tasks is quite dispersed, with a 20–60-minute range. The average variation of 9.48 minutes shows that there was significant inconsistency between the drafting speed in participants. The median completion time (55.50 minutes) was higher than the mean (52.36 minutes) and therefore was expressed as a way of the distribution that exhibits a subset of faster completion time. Measurement of timing values were taken at the same time among all the participants and the timing values of the participants were consistent. Coupled with the performance statistics, the results of these timing outcomes give a complete quantitative profile of the ex-execution of manual drafting under the experimental conditions. This data sets a full initial baseline on working drawings that have been constructed manually before any inferential analysis can be made.

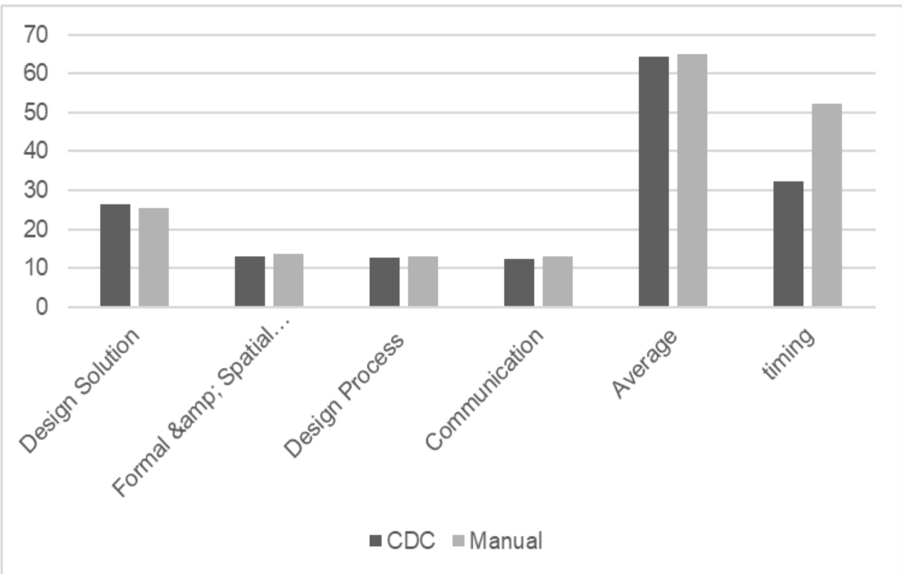
3.3. Comparative Statistical Analysis Between Drafting Methods

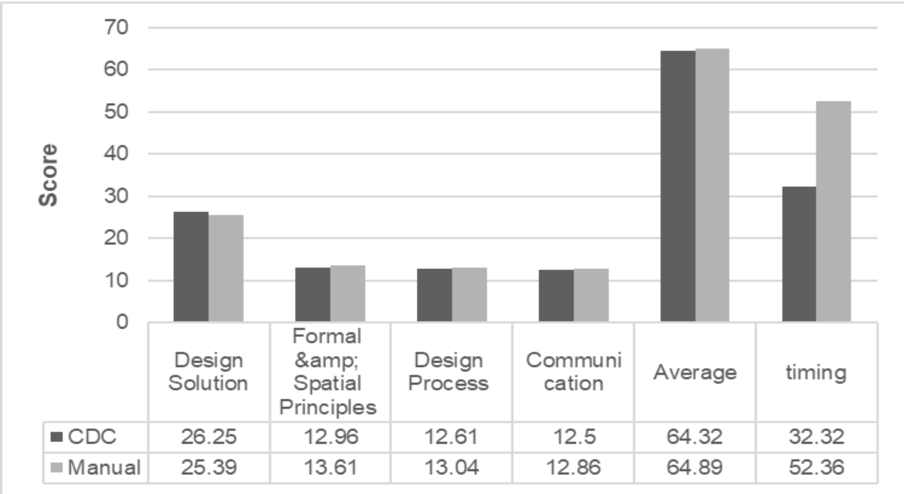
In this section, the findings of the inferential statistical overall analysis made to test the evidence of differences between the computer-generated and manually-generated interior design working drawings are presented. To test the hypotheses of the existence of statistically significant differences in the two drafting methods in six variables assessed, an independent-sample t-test was used. These variables entailed four dimensions of performance, a total average score, and time taken to complete tasks. All tests were performed with the sample size equal to n = 28, with the same subjects providing data to the two conditions. The traditional alpha level of p 0.05 was used to measure the statistical significance. The rationale behind this section is to remove unnecessary instances of statistical testing results that have been described previously.

The inferential test was aimed at identifying the differences between the methods in the quality of design, the performance of procedure, the effective expression of ideas, and efficiency. The independent-sample t-tests had inputs of the mean scores and standard deviations of the two drafting methods. The resulting t-values provide a quantification of the standardised difference between means of groups and resultant p-values provide an indication of whether the observed differences are greater than that of random sampling variation. This analytical model can be used to identify statistically significant and non-significant results. The entire explanation of the inferential results is conclusively summarised in table 4. The results are further broken down into sub tables that are further disaggregated by the performance dimension to make them easier to read.

Table 4: Independent-Sample T-Test Comparing Computer-Created and Manually-Created Designs (N = 28).

Variable	Cad (mean ± sd)	Manual (mean ± sd)	T-value	P-value
Design solution (40%)	26.25 ± 7.06	25.39 ± 6.10	0.489	0.423
Formal & spatial principles (20%)	12.96 ± 3.37	13.61 ± 2.99	−0.755	0.728
Design process (20%)	12.61 ± 3.75	13.04 ± 3.26	−0.456	0.888
Communication (20%)	12.50 ± 3.74	12.86 ± 3.44	−0.372	0.980
Overall average (%)	64.32 ± 17.46	64.89 ± 14.67	−0.133	0.670
Timing (min)	32.32 ± 9.96	52.36 ± 9.48	−7.709	≤ 0.001





The study compared the effectiveness of computer-designed and manually-created designs across five categories: design solution, formal & spatial principles, design process, communication, and timing. The absence of statistically significant differences across quality dimensions supports previous theoretical perspectives that position drafting media as execution platforms rather than determinants of conceptual design quality (Goldschmidt, 2017; Ibrahim & Rahimian, 2010).

3.4. Design Solution (40%) Comparison

The independent-sample t-test made on the design solution dimension provided t -value of 0.489 and a p-value of 0.423. This finding means that the difference in the average scores of computer-created designs (m = 26.25, sd = 7.06) versus those of the manually-created designs (m = 25.39, sd = 6.10) had no statistical significance. The size of the t-value implies that there is weak differentiation between group means as compared to variability within groups. This implies that another null hypothesis is rejected as the p-value is greater than the set level of significance. This result shows statistical equality between drafting methods in the solutions of quality.

Table 5: Independent-Sample T-Test for Design Solution (40%)

Method	Mean ± sd	T-value	P-value
Cad	26.25 ± 7.06	0.489	0.423
Manual	25.39 ± 6.10		

3.5. Formal And Spatial Principles (20%) Comparison

In the formal and spatial principles dimension, the analysis gave t-value as -0.755 and p-value of 0.728. The score of manual drafting (m = 13.61, sd = 2.99) was slightly higher than cad (m = 12.96, sd = 3.37) and the difference was not significant. The t-value is negative pointing to the direction of the difference in the means but with no inference bearing in the non-significant results. The large p-value means that there is extensive overlap of score distributions. These findings affirm the fact that the medium of drafting did not influence spatial reasoning and formal articulation.

Table 6: Independent-Sample T-Test for Formal and Spatial Principles (20%)**

Method	Mean ± sd	T-value	P-value
Cad	12.96 ± 3.37	−0.755	0.728
Manual	13.61 ± 2.99		

3.6. Design Process (20%) Comparison

The design process dimension had a t-value of -0.456 and p-value of 0.888 meaning that there was no statistically significant difference between drafting methods. Manual drafting (m = 13.04 sd = 3.26) marginally scored highly compared to cad (m = 12.61 sd =3.75). Nonetheless, the very high p-value indicates that such difference lies squarely within the range of chance variation. The insignificance of the t-value of the difference in the means of the groups is also a strong indication of the lack of meaningful difference. These results show that there is a similarity in carrying out procedures in both drafting conditions.

Table 7: Independent-Sample T-Test for Design Process (20%).

Method	Mean ± sd	T-value	P-value
Cad	12.61 ± 3.75	−0.456	0.888
Manual	13.04 ± 3.26		

3.7. Communication (20%) Comparison

The t-value and p-value of the case of communication dimension were found to be -0.372 and 0.980 respectively. Cad and manual drafting (m = 12.50, sd = 3.74, and m = 12.86, sd = 3.44) had almost similar mean scores. The p-value of nearly unity shows that the score distributions occurring are virtually overlapping. This result indicates that the readability, legibility, and communicative capability of working drawings were statistically the same between drafting methods. Both methods were not found to have a communication.

Table 8: Independent-Sample T-Test for Communication (20%).

Method	Mean ± sd	T-value	P-value
Cad	12.50 ± 3.74	−0.372	0.980
Manual	12.86 ± 3.44		

The overall comparison of the average scores on performance generated t-value of -0.133 with p-value of 0.670. The average score of the cad (m = 64.32, sd = 17.46) was near that of the manual drafting (m = 64.89, sd = 14.67). Minimal t-value means that there is no significant difference between conditions both in terms of standardisation. The p-value of 0.003 is not significant, which proves that there is no overall performance difference. These findings indicate similarity in cumulative learning outcomes when using drafting practices.

Table 9: Independent-Sample T-Test for Overall Average Score.

Method	Mean ± sd	T-value	P-value
Cad	64.32 ± 17.46	−0.133	0.670
Manual	± 14.67		

Unlike the performance-based variables, the timing comparison showed that the drafting methods differed significantly in a statistical manner. The independent-sample t-test has yielded a t-value of -7.709 and a p-value of = 0.001. The average time of completion of cad (m = 32.32 min, sd = 9.96) was significantly lower than the average time of completion of manual drafting (m = 52.36 min, sd = 9.48). The t-value is very large and it means that there is a strong standardised difference as compared to the within-group variability. That finding confirms that computer-created designs have a statistically significant efficiency advantage.

Table 10: Independent-Sample T-Test for Timing (Minutes)

Method	Mean ± sd	T-value	P-value
Cad	32.32 ± 9.96	−7.709	≤ 0.001
Manual	52.36 ± 9.48		

Generally, the section has established the compared variables based on the effectiveness of computer-designed and manually-created designs across five categories: design solution, formal & spatial principles, design process, communication, and timing. An independent samples t-test was conducted to compare scores between computer-designed and manually created designs.

1. **Design solution**: There was no significant difference in design solution scores between the computer-designed (m = 26.25, sd = 7.064) and manual (m = 25.39, sd = 6.100) groups; t (28) = 0.49, *p* = .423.
2. **Formal & spatial principles:** there was no significant difference in formal & spatial principles scores between the computer-designed (m = 12.96, sd = 3.372) and manual (m = 13.61, sd = 2.986) groups; t (28) = -0.76, *p* = .728.
3. **Design process:** there was no significant difference in design process scores between the computer-designed (m = 12.61, sd = 3.755) and manual (m = 13.04, sd = 3.260) groups; t (28) = -0.46, *p* = .888.

4. **Communication:** There was no significant difference in communication scores between the computer-designed (m = 12.50, sd = 3.737) and manual (m = 12.86, sd = 3.440) groups; t (28) = -0.37, $p = .980$.
5. **Overall average:** there was no significant difference in the overall average scores between the computer-designed (m = 64.32, sd = 17.463) and manual (m = 64.89, sd = 14.673) groups; t (28) = -0.13, $p = .670$.
6. **Timing:** there was a significant difference in timing scores between the computer-designed (m = 32.32, sd = 9.963) and manual (m = 52.36, sd = 9.480) groups; t (28) = -7.71, $p < .001$.

4. DISCUSSION

These study findings make a clear and empirically based contribution to a long-standing debate involving the pedagogical value of computer-aided design (cad) as opposed to manual drafting in interior design working drawings. The findings prove that with cad, the drafting performance is also much improved, but there is no statistically significant difference between the cad and the hand drafting in terms of the achieved learning outcomes. In all the quality dimensions considered, including design solution, formal and spatial principles, design process, communication, and overall performance, both methods of drafting showed statistically equal outcomes. This overlap is a strong indication that the intellectual requirements of working drawings are still the same ones as they were before the drafting medium. This outcome is consistent with theoretical perspectives that position drawing primarily as a cognitive process rather than a purely representational activity. Goldschmidt (2017) emphasizes that design thinking emerges from internal processes of mental imagery, spatial reasoning, and reflective iteration rather than from the drawing medium itself. Similarly, Ibrahim and Rahimian (2010) observed that when students possess adequate design training, both digital and manual tools can produce comparable design outcomes. The present findings therefore reinforce the argument that drafting tools primarily function as platforms for executing design ideas rather than as determinants of conceptual quality.

The lack of substantial differences in the design quality coincides with the previous studies that have stressed the cognitive effect of media drafting as a neutral phenomenon. According to Goldschmidt (2017), design thinking finds its basis in mental images, spatial thinking, and subsequent reflection instead of just using representational tools (pp. 7782). On the same note, Ibrahim and Rahimi an (2010) discovered that cad and manual drawing yielded similar design results where the students had a good background in designs. The existing findings support such theoretical stance as they are the first indication that the capacity to produce correct, spatially consistent and communicative efficient working drawings can be provisional in students regardless of using digital means. Rather there seems to be a conceptual rigor maintained in both of these drafting modalities.

Although there is similarity in quality-related results, statistical significance in the difference in time taken to complete the tasks reveals a clear operational advantage of CAD. The values of speed and efficiency of drafting during CAD conditions are supported by other studies that indicated CAD to be faster and more efficient and achieve the same drafting quality (Ozkan and Yildirim, 2016). Automation options are more in the form of copy, layer control, and fast alteration capabilities, which do not change the design intent but rather minimise redundant motor tasks. Fakhry et al. (2021) also found that CAD hastens the production of working drawings, especially in exam settings, with no inherent increase in understanding. The current research builds upon these results to achieve efficiency gains quantitatively by controlling the time as a variable that will distinguish between the conditions. These results further reinforce the broader literature that highlights the operational advantages of digital drafting tools in technical documentation environments. Previous studies have shown that CAD systems streamline drafting workflows through automation, editing flexibility, and standardized representation tools (Ozkan and Yildirim, 2016). Similarly, Fakhry et al. (2021) demonstrated that CAD significantly reduces production time for architectural working drawings while maintaining comparable quality. The present findings, therefore, provide additional empirical evidence supporting the efficiency benefits of CAD in interior design education contexts.

The fact that formal and spatial principles, and the design process outcomes, are equivalent highlights the still-to-this-day pedagogical significance of manual drafting. This aligns with earlier research emphasizing the cognitive benefits of manual drawing in design education. Studies have suggested that hand drawing strengthens spatial understanding and procedural awareness by engaging continuous hand–eye coordination and proportional judgment (Yildirim and Kasal 2005). Goldschmidt (2017) also argues that sketching supports reflective thinking processes during design development. The comparable outcomes observed in this study therefore suggest that manual drafting continues to contribute to cognitive skill development even when digital tools dominate contemporary design workflows. Relying on manual techniques, a continuous and deliberate hand-eye coordination, relative judgement, and instantaneous spatial reasoning processes were needed, which Bairaktarova (2017) describes as being crucial to strengthening geometric cognition and procedural knowledge. Islamoglu and Deger (2015) also note that hand drawing allows forming more significant involvement of space relationships in the initial and intermediate design phases. The existing evidence suggests that, when students already have training in the two methods, manual drafting continues to make its cognitive contribution despite less efficiency.

It does not differ in its quality of communication which also further undermines the premise that, due to its digital precision drawings gain drawing legibility or clarity. Communication effectiveness in interior drawings is more due to representational conventions and design literacy than drafting medium, as demonstrated by Açici and Sönmez (2014). These current findings identify that, with a fair level of training, both cad and manual drafting have an equivalent ability to reflect design intent amongst students. This concurs with the finding that technology adoption in and of itself does not reshape communicative competence; instructional strategy and representational discipline are more important factors supporting the conclusion of Pektaş and Erkip (2006).

These pedagogical implications are a mixed approach to teaching, in which CAD and manual drafting are consciously combined. Efficiency, professional alignment, and accuracy of documentation must be tapped through CAD use, especially when it is applied in advanced coursework and evaluation environments. On the other hand, manual drafting is to be maintained to allow the aid of spatial cognitions, process awareness, and conceptual grounding, particularly at the initial stages of design, as well as documentation of a site. Such a moderate position is in line with suggestive ideas of Gul (2015) and Fakhri et al (2021), who believe that the most successful outcomes of design education are achieved through the complementary application of both approaches. In conclusion, the findings indicate that the primary focus in drafting education should be on cognitive over technological supremacy, whereby tools will be used as facilitators and not drivers of learning.

5. CONCLUSION

This paper critically analysed the pedagogical and operational effects of computer-aided design and hand drafting in working drawings of interior design coursework. The results confirm that although CAD is statistically significantly superior with regard to execution time, it is not better in terms of learning outcomes in comparison with traditional hand drafting, in terms of design quality, spatial reasoning, process execution, communication clarity, or overall performance. The similarity of the qualitative results highlights the cognitive constituency of design thinking regardless of the medium used to draft the paper, which shows that conceptual knowledge and representational skill are determined not so much by technological devices, but rather by instructional design. As a result, drafting media is to be interpreted as agents of action, but not as determinants of learning depth or designing intelligent processes.

By employing a controlled experimental framework and a standardized multidimensional assessment rubric in interior design education, this paper contributes empirical evidence to a field where direct comparative data on drafting methods remain limited. Statistical testing of both performance quality and timing variables provides methodological clarity to the ongoing debate about digital versus manual drafting in technical coursework.

Educationally and theoretically, the findings support known frameworks of design cognition methodologies in place, in which three recurrent modes of mental simulation, spatial reasoning, and iterative reflection are discussed as fundamental elements in learning. The manual drafting process still remains vital in the development of such cognitive operations, especially in strengthening the sense of space and discipline of the procedure, and CAD boosts productivity by automating and precision. The combination of these assets imposes the implication that when pedagogical performance is given the priority, neither approach should be considered by the other. These results can be added to the discussion on digital change in design education, and they are additionally used to advocate for pedagogical balance over technological replacement.

It is therefore suggested based on these findings that the interior design curriculum take up a hybrid approach form of teaching whereby the use of manual drafting is predominant in the initial stages of design development and conceptual training, whereas cad is utilised tactically to ensure that advanced documentation, efficient revisioning, and professional preparation. The strategies used in assessment must take into consideration both cognitive performance and time efficiency without necessarily equating speed to quality of learning. The future studies should focus on longitudinal effects of hybrid drafting instruction, differences in the cognitive load of training on the method, and the effects of newer technologies, including the use of BIM and AI-assisted drafting, on design cognition. These directions will further narrow down evidence-based plans in maximising the results of learning in design education.

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