AN AHP-BASED FRAMEWORK FOR THE EVALUATION OF ARCHITECTURAL WORKING DRAWINGS

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Abstract. The Analytic Hierarchy Process (AHP) has significant potential in supporting objective evaluations of architectural work, especially during technical design phases and when developing working drawings. This paper proposes a methodology for systematically evaluating CAD-developed architectural working drawings using AHP. The proposed approach uses AHP to break down the evaluation into a hierarchical model of criteria and sub-criteria, assessing drawings created by practicing architects. Weights for each criterion and sub-criterion were determined through AHP, with input obtained from expert questionnaires to ensure accuracy and credibility. The criterion of ‘drawing accuracy and quality’ was assigned a local weight of 0.75, while ‘drawing completeness’ was assigned 0.25. Sub-criterion weights were calculated and ranked according to their importance. The novelty of this work lies in prioritizing criteria within a hierarchy of importance, helping architects organize workloads and serving as a self-assessment tool to enhance work quality and productivity. Establishing a structured assessment method applicable across educational and professional contexts can support future studies on working drawings produced under varying conditions, including lighting and spatial configurations.

Key words: analytic hierarchy process, multi-criteria decision-making, objective evaluation, productivity

1. Introduction

The creation of working drawings is fundamental to the architectural design process. As outlined in the RIBA Plan of Work, these drawings are typically generated between Stage 4, referred to as 'technical design,' and Stage 5, known as 'manufacturing and construction' (RIBA, 2020). This phase is often the most extensive and time-consuming aspect of the design process, comprising approximately 40% of an architect's workload (Elbellahy, 2020). In this study, the term “working drawings” refers specifically to detailed technical documentation prepared for construction purposes, including plans, sections, elevations, schedules, and details. This usage is distinct from conceptual or schematic drawings, which are produced in earlier design phases to communicate design intent rather than provide construction information (Simmons et al., 2012; RIBA, 2020; Kilmer and Kilmer, 2021).

The quality of working drawings plays a crucial role in their utility and the clarity of the conveyed information (Hämäläinen, 2007). Ambiguous or incomplete documentation can lead to significant disruptions during the construction phase and diminish the project's technical specifications (Jarkas and Bitar, 2012; Afzal *et al.*, 2024). Approximately 50% of defects identified during a building's operational phase are linked to inadequacies in the preparation of construction documents (Albukhari, 2014).

It is therefore essential to develop objective evaluation systems to support the production of standards-based working drawings (Hämäläinen, 2007). Evaluation is defined as the procedure undertaken to pass value judgments on a subject’s functionality, effectiveness, outcomes, or worth based on a set of standards (Eilouti, 2019; Elbellahy, 2020). It facilitates the assignment of meaning to a subject’s importance, merit, or quality. Criteria-based evaluation models facilitate the straightforward interpretation of working drawings, allowing design team members to identify limitations and suggest improvements.

However, achieving an objective evaluation of working drawings is a challenging task. This difficulty can be partly attributed to the “undetermined” (Dorst, 2003) and ill-defined nature of design problem-solving (Cross, 2001; Eilouti, 2019). Additionally, the presence of "various implicit layers and tacit heuristics underlining [architectural design] knowledge" makes design one of the most complex skills to execute, teach, and learn (Eilouti, 2019). These factors contribute to making the process of evaluating the quality of working drawings both complex and challenging.

Designers’ frustration with the lack of transparency in evaluation methods is also often seen in educational settings. According to Musa (2020), only 20% of students reported that the jury assessment criteria were clear. Students also observed inconsistency among different jurors’ evaluation standards. Elbellahy (2020) reports discrepancies of up to 50% between different evaluations of design and working drawings. Alagbe *et al.* (2015) highlight a statistically significant difference in students’ scores resulting from variations in evaluation parameters.

Most empirical studies proposing objective evaluation methods also tend to focus on educational contexts (Elbellahy, 2020; Eilouti, 2019). In Elbellahy (2020), a criteria-based model is proposed for students to self-evaluate their working drawings for building floor plans, vertical sections, and construction details. Eilouti (2019) proposes an ‘evaluation wheel’ to assist both designers and educators in systematically judging outputs. While these efforts are aimed at educational environments, architecture schools are regarded as a starting point to improve architects' production of technical drawings and details in professional practice (Celadyn, 2020). Evaluation methods applied in architecture schools may also support the propagation and proliferation of evidence-based and performance-based design processes, which are necessary from a building science and technical perspective (Juaristi *et al.*, 2020).

2. Analytic Hierarchy Process (AHP) to support the evaluation of architectural working drawings; Literature review

Adopting a rational worldview of architectural design as a step-by-step decision-making process opens up the possibility of applying multi-criteria decision-making (MCDM) methods, such as the Analytic Hierarchy Process (AHP), for evaluation. MCDM originates from management and operational fields, involving complex mathematical tools and numerical comparisons to produce integrated and balanced assessments. The use of MCDM in architecture, the built environment, and urban planning is becoming increasingly widespread (Ogrodnik, 2019).

AHP, developed in 1980 by Thomas L. Saaty (Saaty, 1980), is a multi-criteria decision-making (MCDM) tool widely adopted in various research disciplines for its flexibility and ability to facilitate complex expert evaluations easily (Harputlugil *et al.*, 2014). AHP enables the evaluation of both quantitative and qualitative aspects of a problem on the same measurement scale. To achieve this, the initial problem is deconstructed into a hierarchical structure of main criteria, sub-criteria, and second-level sub-criteria, establishing unidirectional hierarchical relationships between upper and lower levels (Andreolli *et al.*, 2022). Experts are then asked to assign relative importance to each element through pairwise comparisons, which establish the dominance of one criterion over another.

A review of the literature reveals the extensive application of AHP methods in built environment research. Table 1 presents studies at both building and urban scales. These serve as examples of common topics where AHP is applied, along with the reasons for its use. This list is not exhaustive; conducting a systematic review of AHP's application in built environment research is beyond the scope of this article. However, a pattern that appears to emerge suggests that AHP is typically used for existing situations and/or currently constructed buildings, such as evaluating current conditions or suggesting improvements for existing structures or scenarios. Articles discussing the use of AHP in early planning stages are limited. These are reviewed in the remaining part of this section.

In Harputlugil *et al.* (2014), AHP is used to evaluate the design quality of a hospital building from its early design stages through to post-completion and post-occupancy evaluation (POE). AHP is used to collect, interpret, and fully integrate the decision perspectives of key stakeholders, including members of the design team and hospital users. Surveys were conducted with 29 stakeholders, and the results identified three main criteria labeled 'build quality,' 'functionality,' and 'impact,' along with numerous sub-criteria.

Table 1. Review of articles in built environment literature showing the nature of topics in which AHP is used (Source: Authors).

Reference	Study country	Overarching topic	Purpose of using AHP	Scale
AbdelAzim *et al*. (2017)	Egypt	Development of tools to optimize energy efficiency/ building performance.	To develop a criteria-based rating system for existing buildings based on their energy consumption. AHP was used to develop the weights of the 9 criteria of the proposed rating system.	Building scale
De Paris *et al*. (2021)	Portugal and Brazil	Housing adaptability and flexibility	To determine the levels of importance of different criteria pertaining to adaptability and flexibility, with a particular focus on housing apartments, especially when these have limited space for transformation.	
Gao *et al*. (2021)	Malaysia / Nigeria	Indoor Environmental Quality (IEQ)	To build an assessment tool for quantifying the 'sickness' component of sick building syndrome (SBS) during the planning stage, a checklist of known SBS factors was used to identify contributing indices, which were then structured into a hierarchical framework using AHP.	
Banti and Krawczyk (2024)	Italy	Building energy retrofitting / refurbishment.	To develop four alternative heating systems for retrofitting industrial buildings, their energy performance was simulated using DesignBuilder, and a multi-criteria model incorporating AHP was applied to weight and rank evaluation criteria.	
Yilmaz *et al.* (2024)	Turkey	Smart materials / Smart systems.	To select appropriate thermal insulation materials for the improvement of a residential building envelope's thermophysical properties.	
Awad and Jung (2022)	Dubai, United Arab Emirates	Sustainable Urban Regeneration	To identify and prioritize key planning elements (e.g., urban environment, economic, social/cultural, transportation, sustainability) for sustainable urban regeneration in Dubai using AHP, guiding future projects.	Urban scale
Aromal and Naseer (2023)	India	Pedestrianization / Transportation	To rate factors affecting walkability and the extent to which they enhance they improve pedestrian facilities.	
Asaad *et al*. (2023)	Egypt	Green neighborhoods.	To establish a framework that ranks countries of the MENA region according to their achievements in establishing green certification at the neighborhood scale.	
El-Kholei *et al*. (2024)	Egypt	Urban sustainability	To ascertain the criteria for sustainable urban design and to determine the challenges experienced by urban designers and planners in achieving sustainable urban development.	
Qiao *et al*. (2025)	China	Cultural heritage evaluation	To assess the heritage value and prioritize conservation efforts using AHP integrated with fuzzy control for better accuracy.	

In Ciftcioglu and Sariyildiz (2005), AHP is used to establish hierarchical relationships among key design elements, including loads, materials, form and space geometry, structural design approach, and structural behavior. In Bitarafan *et al.* (2015), AHP is used to identify the most suitable architectural forms for civil defense, with results indicating that a center-oriented form is optimal for this purpose.

In Simsek (2019), AHP was employed to evaluate student work and determine which of the three proposed designs was the most effective solar architecture project based on weighted performance scores. Harputlugil (2018) also explores the use of AHP in an educational setting by implementing the method to assess outputs from an architectural design studio. The objective is to adapt AHP for traditional project assessment in design juries. Findings showed that although the project rankings from both methods were similar, the AHP approach helped jurors address limitations of traditional assessment, such as clearly defining evaluation criteria and assigning relative weights to each criterion.

While AHP may serve as a rewarding opportunity to support architects and architectural educators, evidence of its use to support tasks undertaken during pre-construction stages is sparse. In the majority of previous scientific research, AHP was used to evaluate conceptual designs rather than detailed designs and the production of technical architectural working drawings (Ciftcioglu and Sariyildiz, 2005; Bitarafan *et al.*, 2015; Simsek, 2019). This is despite findings that evaluation criteria-based tools are easier and more straightforward to use in the judgment of objective function rather than the conceptual design or building forms (Eilouti, 2019).

The selection of AHP for this study was evaluated in comparison to the advantages of other MCDM methods, such as the Technique for Order of Preference by Similarity to Ideal Solution TOPSIS and the Delphi method. The AHP was chosen due to its structured pairwise comparison mechanism, which ensures transparency and consistency in expert judgments (Saaty, 1980; Andreolli *et al.*, 2022). Unlike TOPSIS, which is primarily suited for ranking alternatives when quantitative performance data are already available, AHP allows evaluators to derive relative weights based on subjective expert input (Ogrodnik, 2019; Aromal and Naseer, 2023). Similarly, while the Delphi method is effective for achieving consensus building among experts through iterative rounds of discussion, it does not provide a quantitative hierarchy or consistency check within the evaluation process (Ogrodnik, 2019; Aromal and Naseer, 2023).

The authors of this work, therefore, hypothesize that AHP may have significant potential in supporting architectural work during the technical design stages, such as developing working drawings. They aim to identify the key factors that need to be considered when evaluating working drawings. Additionally, they seek to understand the relative and overall importance of each factor and whether a ranking system can be created to order them. By demonstrating how AHP was used to evaluate tasks performed by practicing architects in an experimental study designed to assess architects' productivity, the authors aim to contribute to the understanding of using AHP to evaluate architectural working drawing tasks in general, as illustrated in Fig. 1 below.

Following the background and literature review sections, the remainder of this article is structured as follows. A case study is introduced in Section 3, illustrating the evaluation of computer-based tasks using the Analytic Hierarchy Process (AHP). Section 3.1 outlines the definition of main and sub-criteria, while Section 3.2 details the recruitment of domain experts who completed a questionnaire to assign relative importance to the identified criteria. Section 3.3 describes the implementation of AHP, including pairwise comparisons, consistency checks, and the derivation of final weights. Section 4 presents the results, including the calculated criteria weights and the ranking of both first- and second-level sub-criteria based on local and global weights (Section 4.1). A proof-of-concept is then provided in Section 4.2, demonstrating the practical application of the proposed framework to evaluate and score working drawings produced by a participant in the repeated measures experiment. The broader implications of the findings are discussed in Section 5, while Section 6 offers concluding remarks and outlines potential directions for future research.

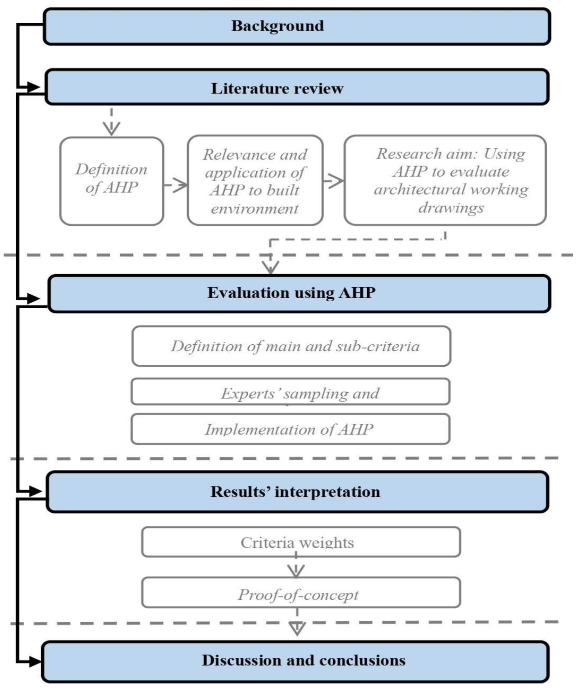


Fig. 1. Research framework undertaken in this study (Source: Author).

3. Methodology

A repeated measures experiment was designed to quantitatively evaluate architects' productivity in an open-plan setting. Employee productivity refers to the efficiency and effectiveness with which employees undertake tasks and achieve organizational goals (Ployhart *et al.*, 2014). A space measuring approximately 60 m² (10.25 m x 5.80 m) served as a controlled environment, mimicking an open-plan space. For experimental purposes, practicing architects were asked to complete four computer-based tasks, each consisting of technical working drawings, produced over a 20-minute interval under predefined conditions. Convenience sampling was used to recruit participants for the experiment.

All participants were employees of local architectural firms and were required to have a professional working knowledge of Autodesk AutoCAD (also referred to as AutoCAD). AutoCAD is a powerful tool for technical communication, allowing designers to convey their intentions and goals accurately and efficiently (Simmons *et al.*, 2012). Its precision and versatility make it suitable for tasks such as drafting (Fakhry *et al.*, 2021), creating detailed drawings, and ensuring accuracy in architectural plans (McConnell and Waxman, 1999). The software is widely used in architectural firms, as it has been found to yield improved quality of construction drawings (Fakhry *et al.*, 2021).

The purpose of using AHP in this study was to evaluate the computer-based tasks produced by participants, based on the AHP framework shown in Fig. 2 below. AHP was employed to break down the research problem into a hierarchical structure that delineates the main goal (assessment of computer-based tasks), main criteria, sub-criteria, and indicators corresponding to each sub-criterion.

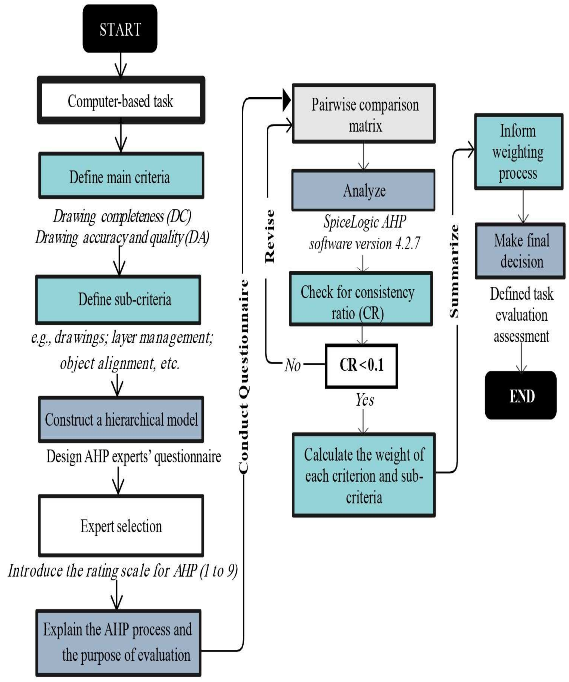


Fig. 2. Analytic Hierarchy Process (AHP) framework designed for the study (Source: Author).

The proposed AHP-based framework is not intended as an additional task within the architect's design workflow, but as a supportive evaluation tool to be applied by experts, educators, or decision-makers. Its role is to provide structured feedback, strengthen evaluation practices, and facilitate more transparent communication between architects and evaluators.

Given that architectural design requires both technical precision and creative exploration, the framework is positioned not as a substitute for creativity but as a complementary mechanism that supports systematic decision-making and transparent assessment, thereby enhancing rather than restricting the creative dimension of architectural practice.

3.1. Definition of main and sub-criteria

The main criteria and sub-criteria established for this study and used to evaluate the drawings produced were initially defined by the researchers based on a review of relevant literature (Kilmer and Kilmer, 2021; Khawla and Abdelmalek, 2024). Two main criteria, namely 'drawing completeness' (DC) and 'drawing accuracy and quality' (DA), were established. Four sub-criteria under the main 'drawing completeness' criterion were identified, along with three sub-criteria for 'drawing accuracy and quality'. These, together with indicators for each sub-criterion, are outlined in the hierarchical model shown in Fig. 3. The last section focused on criteria weighting. The authors provided a detailed introduction to AHP and the questions experts have to complete. Experts were presented with the hierarchical structure illustrated in Fig. 3.

Using pairwise comparisons, as presented in Table 2, experts were requested to evaluate the relative importance of each pair of elements. They were also informed that all data collected would remain confidential and untraceable to individual participants. The study was approved by the Institutional Review Board (IRB) of Ain Shams University in September 2024 under reference number IRB-ASU-24-001.

A Likert-type scale was provided to quantify these judgments, ranging from 'extreme importance' to 'equal importance' on a 1–9 point scale. According to Saaty (1980), the advantage of employing a 1–9 point scale is that it can provide qualitative distinctions and a broader range of assessments to assess the relative importance of different parameters, as opposed to more minor point scales. This data was then used to calculate weights for each criterion within the hierarchical framework, as discussed in Section 3.3.

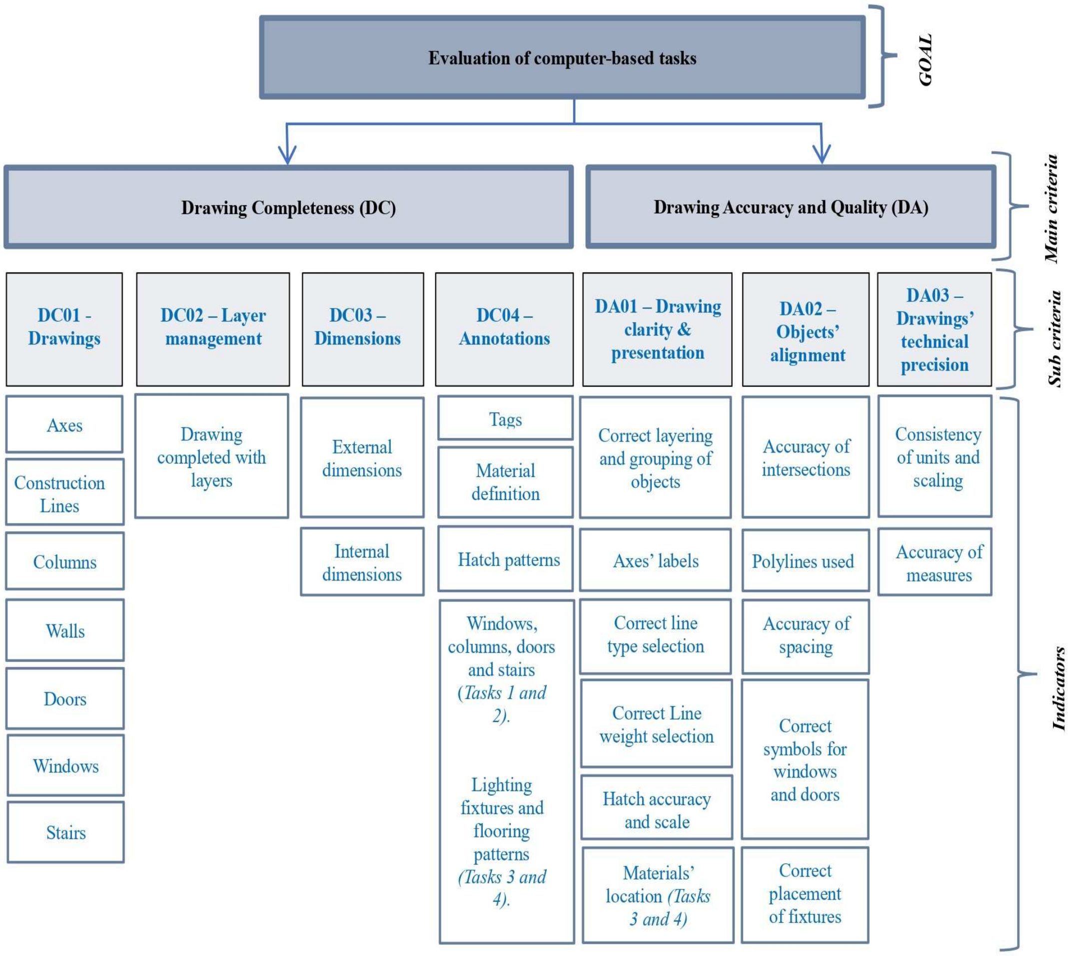


Fig. 3. Hierarchical model of main criteria and sub-criteria established for this study (Source: Authors).

Table 2. Pairwise comparison scale (Source: Saaty, 1980).

Degree of Importance	Definition	Explanation
1	Equal importance	Two elements contribute equally to the objective.
3	Moderate importance	Experience and judgment slightly favor one element over the other.
5	Strong importance	Experience and judgment strongly favor one element over the other.
7	Very strong importance	One element is strongly favored, and its importance is demonstrated.
9	Extreme importance	One element is of the highest possible dominance over another.
2, 4, 6, 8	Intermediate values	Represent a com-promise between the priorities listed above.

3.2. Experts' sampling and selection

Nguyen *et al.* (2022) highlight the necessity of establishing clear criteria for expert selection. These include experts' specialized knowledge directly relevant to the research study, a diverse range of expertise, and a proven commitment to the research project. The number of expert participants tends to be influenced by the complexity of the problem and the availability of qualified experts. The sizes of expert samples participating in AHP questionnaires exhibit considerable variation in built-environment research, ranging from 10 (Wong and Li, 2008) to 13 (Mak *et al.*, 2015), and up to 61 (AbdelAzim *et al.*, 2017).

In this research, the sample size of experts was calculated using Equation 1, as suggested by Viechtbauer *et al.* (2015), and El-Kholei *et al.* (2024). For

π=0.15, a sample size of 18.43 was calculated, meaning that 19 expert participants were needed for a 95% confidence level. Accordingly, the required sample size of experts for completing the decision-making questionnaire is determined using the following equation:

$$n=\ln(1-y)/\ln(1-\pi) \quad \ldots (1)$$

Where:
n=sample size
π = Problem probability
y = confidence levels.

In this study, an AHP-based evaluation questionnaire was administered exclusively to experts, whose role was to provide systematic weighting assessments of the defined criteria, sub-criteria, and indicators according to their relative importance using the AHP scale, which forms the structural basis of the proposed framework. In contrast, the drawing tasks produced during the experiment were completed by practicing architects representing different genders and levels of professional experience, in order to capture a realistic spectrum of design outputs. This clear separation of roles was intended to ensure that the evaluation process remained both independent and methodologically consistent.

A sample of 19 experts, comprising members of the authors' professional network, was collected through convenience sampling. Details of the sample are provided in Table 3. The group included 10 male and 9 female participants, predominantly within the ages of 35–44 (12 participants, 63%), 45–54 (3 participants, 16%), and 55–64 (2 participants, 10.5%), with two participants (10%) aged 65 or older. Their current professional roles included 10 practicing architects (53%) and 15 academic professors (79%). Four participants served as principals of architectural firms, and 63% of the sample held dual or overlapping roles.

All experts had substantial professional experience. Specifically, 37% had between 10 and 15 years of experience, 26% had between 16 and 21 years, and an additional 37% had over 22 years of practice. Educationally, all expert participants held advanced degrees, with 16 (84%) earning doctoral degrees (PhDs) and three experts having completed master's degrees. This combination of extensive practical experience and advanced educational qualifications ensured that the expert group's contributions were founded on a profound and comprehensive understanding of the architecture and building construction industries and disciplines pertinent to the Egyptian context in which this study was conducted.

3.3. Implementation of AHP

All usable questionnaires were analyzed as part of the AHP procedure to establish an objective evaluation system for architectural working drawings. Criteria and sub-criteria were input into the AHP hierarchy using SpiceLogic AHP software version 4.2.7 (SpiceLogic Inc., 2024). This platform was selected based on several advantages, including its user-friendly interface and graphical reports of process steps and numerical data (Ishizaka and Labib, 2009). Features such as automatic priority calculation, real-time consistency control, and sensitivity analysis also contributed to the decision to use SpiceLogic AHP software (Ishizaka and Labib, 2009).

Table 3. Details of AHP experts participating in this study (Source: Authors).

No.	Expert initials	Gender	Age range	Current job title/position	Years of experience	Highest level of education
1.	ZK	Female	35-44	Practicing architect	10-15 years	M.Sc degree
2.	OM	Male	35-44	Practicing architect	10-15 years	M.Sc degree
3.	LG	Female	35-44	Academic professor	10-15 years	PhD
4.	RA	Female	35-44	Academic professor	10-15 years	PhD
5.	GG	Female	35-44	Practicing architect, academic professor	10-15 years	PhD
6.	AJ	Male	35-44	Practicing architect, academic professor	10-15 years	PhD
7.	MR	Male	35-44	Practicing architect, academic professor	10-15 years	PhD
8.	KN	Male	35-44	Academic professor, Principal of architectural firm	16-21 years	PhD
9.	SD	Female	35-44	Academic professor, practicing architect	16-21 years	PhD
10.	DE	Female	35-44	Academic professor	16-21 years	PhD
11.	OG	Female	35-44	Practicing architect, academic professor	16-21 years	PhD
12.	ES	Male	35-44	Practicing architect, academic professor	16-21 years	PhD
13.	TG	Male	45-54	Practicing architect, academic professor	22+ years	PhD
14.	NA	Female	45-54	Practicing architect	22+ years	M.Sc degree
15.	SS	Male	45-54	Academic professor	22+ years	PhD
16.	HM	Male	55-64	Academic professor, Principal of an architectural firm	22+ years	PhD
17	SM	Male	55-64	Practicing architect, Principal of an architectural firm	22+ years	PhD
18	MO	Female	65+	Academic professor, Principal of an architectural firm	22+ years	PhD
19	ME	Male	65+	Academic professor	22+ years	PhD

SpiceLogic AHP facilitated pairwise comparisons by providing an intuitive interface for inputting judgments. A pairwise comparison began to take shape as experts evaluated each pair of criteria and sub-criteria. Experts' input was used to determine reciprocal judgments for the given criteria within the hierarchy. Subsequently, eigenvectors (i.e., weight vectors) were calculated to identify relative priorities among the criteria (Saaty, 1980). Eigenvectors represent the relative importance of criteria in decision-making by transforming subjective judgments into numerical values, enabling a systematic comparison of alternatives. By calculating the eigenvectors, decision-makers can prioritize the alternatives based on the significance of each criterion, ensuring that the most important factors receive greater weight in the decision-making process.

After pairwise comparisons were completed, individual judgments were calculated using the eigenvalue method through the SpiceLogic AHP software, resulting in the formation of a composite priority vector. This aggregation process captured the group's collective preferences, synthesizing diverse opinions into a unified set of priorities that reflected the overall consensus.

To prevent bias, the consistency of the weights was verified using the

Consistency Ratio (CR), calculated according to equations 2 and 3, as described by Saaty (1980). The CR values for this study indicated that all participant responses were consistent, with values of 0.10 or less. The only exception was the responses of four individuals, whose CR values exceeded the threshold of 0.10, indicating inconsistent pairwise comparisons. Consequently, the corresponding questionnaire was revised, and these participants were requested to provide their inputs again to ensure the process's integrity and to achieve an acceptable consistency ratio before finalizing the task assessment rubric. Therefore, the consistency ratio (CR) is calculated as the ratio of the consistency index (CI) to the random index (RI), following the method proposed by Donegan and Dodd (1991). It is represented by the following equations:

$$CI=(\lambda max-n)/(n-1) \quad \ldots (2)$$

Where:
CI = Consistency Ratio
Λmax = Maximum eigenvalue of the pairwise comparison matrix
n = The number of criteria or alternatives being compared.

$$CR=CI/RI \quad \ldots (3)$$

Where:
CI = Consistency Ratio
RI = Random Index, which is the average consistency index for a large number of randomly generated matrices of the same order (n).

Pairwise comparisons enabled the calculation of local weights (wi) for each main and sub-criterion. Local weights, shown in Tables 4 and 5, reflect the priorities of each main criterion or sub-criterion within individual clusters. Global weights were also computed for each sub-criterion. These weights indicate the priority of each main and sub-criterion relative to the overall goal, as indicated in Table 6. This was achieved by multiplying the local weight of each sub-criterion by the local weight of its corresponding main criterion, thereby establishing the sub-criterion's relative priority and rank.

To facilitate the evaluation of computer-based tasks, Section 4.2 also included points for each sub-criterion, which were computed by multiplying their respective global weights by 100. Additional points were awarded for each indicator's presence, determined by dividing the global weight of each sub-criterion by the number of underlying indicators, as shown in Table 7. In the subsequent evaluation of the four computer-based tasks, a full score was awarded for each indicator present in the drawing. If an indicator was only partially represented, a partial score was assigned based on its accuracy and completeness. Specifically, if an indicator was partially drawn (for example, missing details or only showing part of the required structure), a proportional fraction of the total score was assigned according to its degree of completion. This approach allowed recognition of partial accuracy without completely penalizing participants for incomplete representations.

The criteria used pairwise comparison matrices to evaluate relationships and consistency across comparisons. When comparing two criteria, the reciprocal method was used to assign values in the matrix. If an expert assigns a numerical value to represent the importance of one criterion over another, the reciprocal of that value is used for the reverse comparison. This ensures consistency in the matrix, where the value in one direction is inversely reflected in the opposite direction. Pairwise comparison matrices were also used to analyze priority vectors and ensure that the rankings accurately represented the overall consensus and priorities of the decision-making groups, as depicted in Table 7.

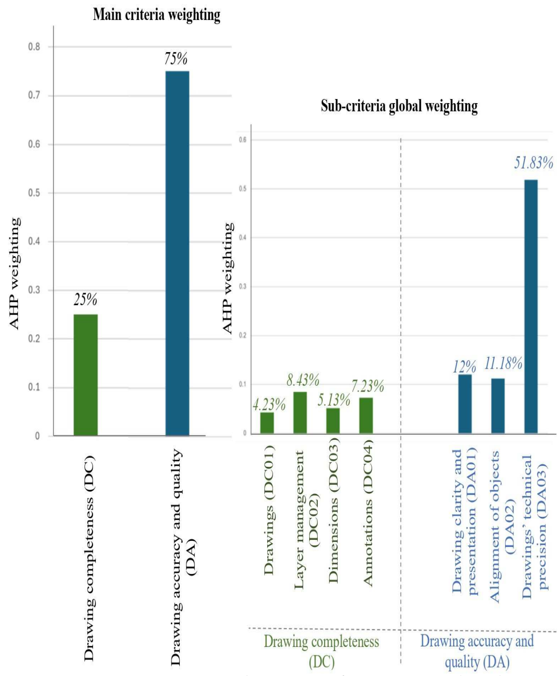


Fig. 4. AHP weightings of main and sub-criteria (Source: Authors).

4. Results

4.1. Criteria weights yielded using the AHP method

At the first level, the main criterion, 'drawing accuracy and quality' (DA), was given the highest importance with a local weight of 0.75 (i.e., Wi = 75%), while the importance weight for 'drawing completeness' (DC) was only 0.25. 'Drawings' technical precision' (DA03) was the highest-ranked sub-criterion in experts' perceived importance, with a local weight of 0.691 and a global weight of 0.5183 (51.83%). In other words, when evaluating architectural working drawings, over 50% of the scores should be based on experts' evaluations of the drawings' technical precision, as shown in Fig. 4.

4.2. Proof-of-concept

To demonstrate a practical example of the framework proposed in this article for evaluating architectural working drawings, this section presents drawings produced during the repeated-measures experiment as proof of concept. The drawings analyzed were produced by three participants representing different performance levels (high, medium, and low). Each participant completed four computer-based drawing tasks 01-04 under the experiment's predefined conditions. The evaluation was conducted in accordance with the framework's main criteria, sub-criteria, and indicators. The total scores for each task are presented in Tables 8, 9, and 10.

The findings reveal a consistent decline in actual productivity. This downward trend is evident across all performance levels, as reflected in the consecutive scores for each participant. For the low-performance participant, the scores decreased from 84.57% in Task 1 to 79.99%, 71.35%, and 59.45% in Tasks 2, 3, and 4, respectively. The medium-performance participant showed a similar pattern, with scores of 87.57%, 84.29%, 77.03%, and 71.56% across the four tasks. Likewise, the high-performance participant recorded 95.21%, 93.03%, 91.62%, and 88.12% for Tasks 1 through 4.

Table 4. Pairwise comparison matrix of 'drawing completeness' (DC) sub-criteria (Source: Authors).

Matrix		**Drawings**	**Layer management**	**Dimensions**	**Annotations**	**Normalized principal eigenvector**	**Consistency Ratio (CR)**
		1	2	3	4		
Drawings	1	1	1/2	1	1/2	16.92%	0.022
Layer management	2	2	1	2	1	33.83%	
Dimensions	3	1	1/2	1	1	20.46%	
Annotations	4	2	1	1	1	28.79%	

Table 5. Pairwise comparison matrix of 'drawing completeness' (DC) sub-criteria (Source: Authors).

Matrix		**Drawing clarity and presentation**	**Alignment of objects**	**Drawing technical precision**	**Normalized principal eigenvector**	**Consis-tency Ratio (CR)**
		1	2	3		
Drawing clarity and presentation	1	1	1	1/4	16.03%	0.0
Alignment of objects	2	1	1	1/5	14.88%	
Drawing technical precision	3	4	5	1	69.08%	

Table 6. First and second-level sub-criteria local and global weights (Source: Authors).

Main criteria	**Local Weight (wi)**	**Wi**	**Sub criteria**		**Local weight (wi)**	**Global weight**	**Rank**
Drawing completeness (DC)	0.25	25%	Drawings (DC01)		0.169	0.04225	7
			Layer management (DC02)		0.337	0.08425	4
			Dimensions (DC03)		0.205	0.05125	6
			Annotations (DC04)		0.289	0.07225	5
			Total	Wi = wi x100%	1	0.25	
Drawing accuracy and quality (DA)	0.75	75%	Drawing clarity and presentation (DA01)		0.160	0.12000	2
			Alignment of objects (DA02)		0.149	0.11175	3
			Drawings' technical precision (DA03)		0.691	0.5183	1
			Total	Wi = wi x100%	1	0.75	

Table 7. Showing points awarded for each sub-criterion and indicator used in the evaluation of computer-based tasks (Source: Authors).

Main criteria	**Sub-criteria**	**Total points for each sub-criterion (global weight *100)**	**Indicator**	**Total points awarded for each indicator**
Drawing completeness (DC)	Drawings (DC01)	4.225	Axes	0.60
			Construction Lines	0.60
			Columns	0.60
			Walls	0.60
			Doors	0.60
			Windows	0.60
			Stairs	0.60
	Layer mana-gement (DC02)	8.425	Drawing completed with layers	8.425
	Dimensions (DC03)	5.125	External dimensions	2.56
			Internal dimensions	2.56
	Annotations (DC04)	7.225	Tags	1.81
			Material definition	1.81
			Hatch patterns	1.81
			Fixtures	1.81
	(25 points)			

Main criteria	Sub-criteria	Total points for each sub-criterion (global weight *100)	Indicator	Total points awarded for each indicator
Drawing accuracy and quality (DA)	Drawing clarity and presentation (DA01)	12.000	Correct layering and grouping of objects	2.00
			Axes' labels	2.00
			Correct line type selection	2.00
			Correct line weight selection	2.00
			Hatch accuracy and scale	2.00
			Materials' location	2.00
	Objects' alignment (DA02)	11.175	Accuracy of intersections	2.24
			Polylines used	2.24
			Accuracy of spacing	2.24
			Correct symbols for windows and doors	2.24
			Correct placement of fixtures	2.24
	Drawings' technical precision (DA03)	51.830	Consistency of units and scaling	25.92
			Accuracy in measures	25.92
	(75 points)			
Total=100 Points				

Table 8. Evaluation of computer-based tasks based on the AHP evaluation framework, low-performance participant (Source: Authors).

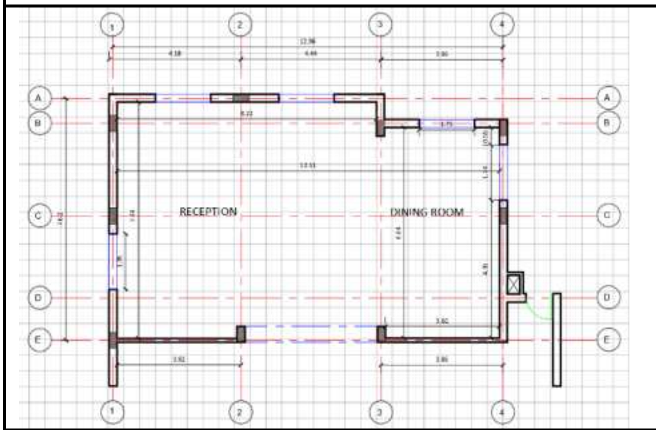
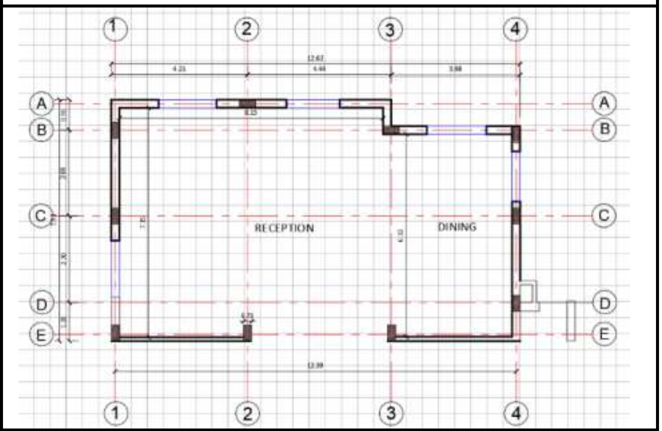
4a: Task 1		**4b: Task 2**	
			
Points awarded for each indicator	**Points awarded for sub-criterion**	**Points awarded for each indicator**	**Points awarded for sub-criterion**
Axes (0.60/0.60)	Drawings (DC01) = 2.90/4.225	Axes (0.6/0.60)	Drawings (DC01) = 2.3/4.225
Construction Lines (0.40/0.60)		Construction Lines (0.4/0.60)	
Columns (0.60/0.6)		Columns (0.6/0.60)	
Walls (0.60/0.60)		Walls (0.6/0.60)	
Windows (0.10/0.60)		Windows (0.10/0.60)	
Doors (0.6/0.60)		Doors (0.0/0.60)	
Stairs/steps (0.00/0.60)		Stairs/steps (0.0/0.60)	
Drawing completed with layers (6.40/8.425)	Layer management (DC02) = 6.40/8.425	Drawing completed with layers (6.42/ 8.425)	Layer management (DC02) = 6.42/8.425
External dimensions (2.20/2.56)	Dimensions (DC03) =4.00/5.12	External dimensions (1.84 /2.56)	Dimensions (DC03) = 3.68/5.12
Internal dimensions (1.80/2.56)		Internal dimensions (1.84/2.56)	
Tags (3.61/3.61)	Annotations (DC04)	Tags (3.61 /3.61)	Annotations (DC04)

Table 8. Evaluation of computer-based tasks based on the AHP evaluation framework, low-performance participant (Source: Authors).

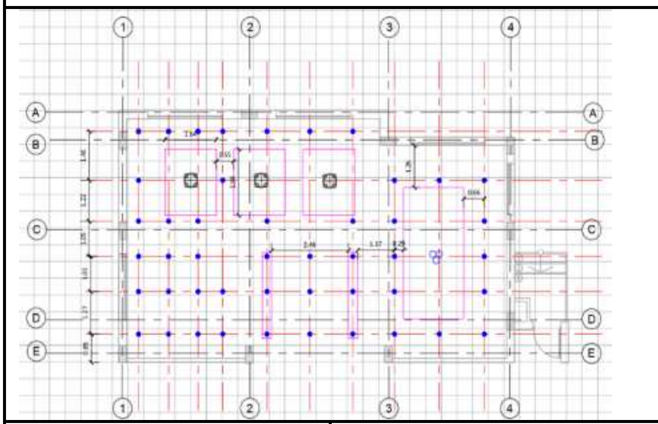
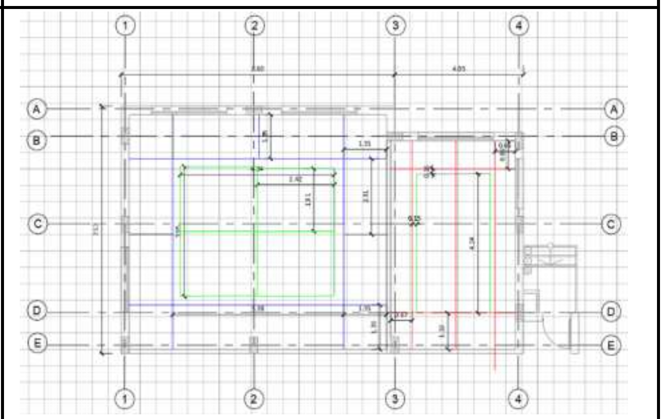
4a: Task 1		**4b: Task 2**	
Hatch patterns (3.61/3.61)	= 7.22 / 7.22	Hatch patterns (3.61/3.61)	=7.22/7.22
Correct layering and grouping of objects (2.0/2.4)	Drawing Clarity and Presentation (DA01) =10.2 / 12	Correct layering and grouping of objects (2.0 2.4)	Drawing Clarity and Presentation (DA01) = 10.2/12
Axes' labels (2.4 /2.4)		Axes' labels (2.4/2.4)	
Correct line type selection (1.4/2.4)		Correct line type selection (1.4/2.4)	
Correct line weight selection (2.0/2.4)		Correct line weight selection (2.0/2.4)	
Hatch accuracy and scale (2.4/2.4)		Hatch accuracy and scale (2.4/2.4)	
Accuracy of intersections (1.24/2.79)	Alignment of objects (DA02) = 4.48/ 11.16	Accuracy of intersections (1.395 /2.79)	Alignment of objects (DA02) =4.79/11.16
Polylines used (2.0/2.79)		Polylines used (2.0/2.79)	
Accuracy of spacing (1.24/2.79)		Accuracy of spacing (1.395/2.79)	
Correct symbols for windows and doors (0.0/2.79)		Correct symbols for windows and doors (0.0/2.79)	
Consistency of units and scaling (25.92/25.92)	Drawing Technical Precision (DA03) = 49.37/51.84	Consistency of units and scaling (23.92/25.92)	Drawing Technical Precision (DA03) = 45.38/51.84
Accuracy in measures (23.45/25.92)		Accuracy in measures (21.46/25.92)	
Drawing completeness (DC) + Drawing accuracy and quality (DA) = (20.52+64.05) = 84.57		Drawing completeness (DC) + Drawing accuracy and quality (DA) = (19.625 + 60.37) = 79.99	
4c: Task 3		**4d: Task 4**	
			
Points awarded for each indicator	**Points awarded for sub-criterion**	**Points awarded for each indicator**	**Points awarded for sub-criterion**
Axes (2.11/2.11)	Drawings (DC01) = 4.22/4.22	Construction Lines (2.225/4.225)	Drawings (DC01) = 2.225/4.225
Construction Lines (2.11/2.11)			
Drawing completed with layers (4.42/8.425)	Layer management (DC02) = 4.42 /8.425	Drawing completed with layers (4.425/8.425)	Layer management (DC02) = 4.425/8.425
External dimensions (1.25/2.56)	Dimensions (DC03) = 2.5/5.12	External dimensions (1.90/2.56)	Dimensions (DC03) = 3.46/5.12
Internal dimensions (1.25/2.56)		Internal dimensions (1.56/2.56)	
Material definition (0.0/3.61)	Annotations (DC04) = 3.61/7.22	Tags (0.0/2.41)	Annotations (DC04) = 1/7.23
		Hatch patterns (1.0/2.41)	
Fixtures (3.61/3.61)		Material definition	

Table 8. Evaluation of computer-based tasks based on the AHP evaluation framework, low-performance participant (Source: Authors).

4a: Task 1		**4b: Task 2**	
		(0.0/2.41)	
Correct layering and grouping of objects (1.20/2.4)	Drawing Clarity and Presentation (DA01) = 6.4/12	Correct layering and grouping of objects (0.80/2.4)	Drawing Clarity and Presentation (DA01) = 3.6/12
Correct line type selection (1.40/2.4)		Correct line type selection (1.40/2.4)	
Correct line weight selection (1.40/2.4)		Correct line weight selection (1.40/2.4)	
Hatch accuracy and scale (2.4/2.4)		Hatch accuracy and scale (0.0/2.4)	
Materials' location (0.0/2.4)		Materials' location (0.0/2.4)	
Accuracy of intersections (1.24/2.79)	Alignment of objects (DA02) = 6.82/11.2	Accuracy of intersections (1.845 /3.69)	Alignment of objects (DA02) = 5.38/11.07
Polylines used (1.79/2.79)		Polylines used (1.845/3.69)	
Accuracy of spacing (2.0/2.79)		Accuracy of spacing (1.69/3.69)	
Correct placement of fixtures (1.79/2.79)			
Consistency of units and scaling (23.92/25.92)	Drawing Technical Precision (DA03) = 43.38/51.84	Consistency of units and scaling (23.92/25.92)	Drawing Technical Precision (DA03) = 39.38/51.84
Accuracy in measures (19.46/25.92)		Accuracy in measures (15.46/25.92)	
Drawing completeness (DC) + Drawing accuracy and quality (DA) = (14.145 + 56.6) = 71.35		Drawing completeness (DC) + Drawing accuracy and quality (DA) = (11.05+48.36) = 59.47	

Table 9. Evaluation of computer-based tasks based on the AHP evaluation framework, medium-performance participant (Source: Authors).

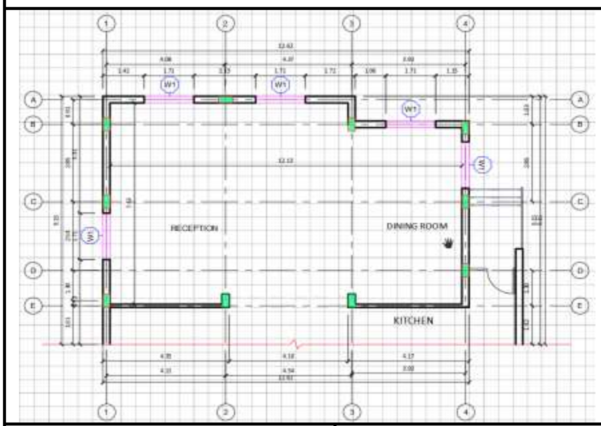
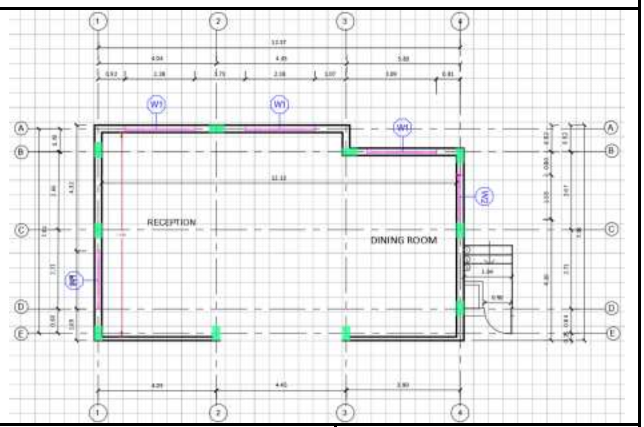
4e: Task 1		**4f: Task 2**	
			
Points awarded for each indicator	**Points awarded for sub-criterion**	**Points awarded for each indicator**	**Points awarded for sub-criterion**
Axes (0.60/0.60)	Drawings (DC01) = 4.000/4.225	Axes (0.60/0.60)	Drawings (DC01) = 4.225/4.225
Construction Lines (0.60/0.60)		Construction Lines (0.60/0.60)	
Columns (0.60/0.6)		Columns (0.60/0.60)	
Walls (0.60/0.60)		Walls (0.60/0.60)	
Windows (0.6/0.60)		Windows (0.60/0.60)	
Doors (0.6/0.60)		Doors (0.60/0.60)	
Stairs/steps (0.40/0.60)		Stairs/steps (0.60/0.60)	

Table 9. Evaluation of computer-based tasks based on the AHP evaluation framework, medium-performance participant (Source: Authors).

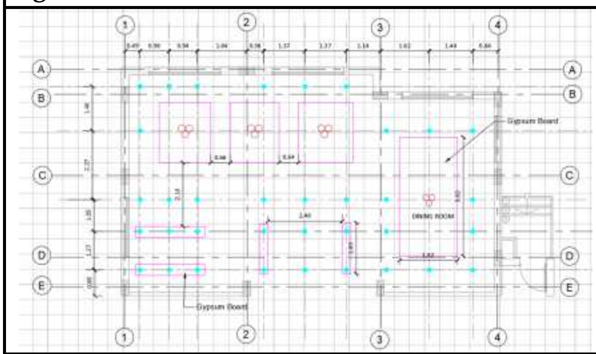
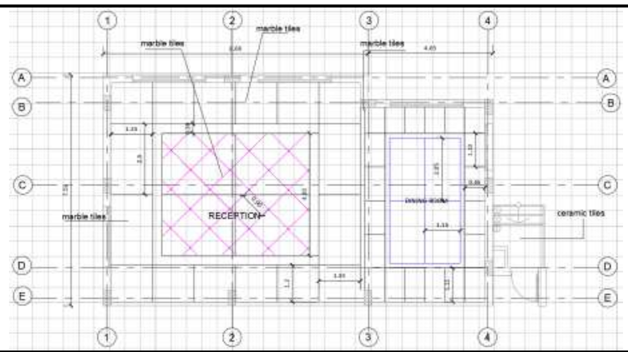
4e: Task 1		**4f: Task 2**	
Drawing completed with layers (7.425/8.425)	Layer management (DC02) = 7.425/8.425	Drawing completed with layers (7.425/ 8.425)	Layer management (DC02) = 7.425/8.425
External dimensions (2.56/2.56)	Dimensions (DC03) = 4.56/5.12	External dimensions (2.20 /2.56)	Dimensions (DC03) = 4.20/5.12
Internal dimensions (2.00/2.56)		Internal dimensions (2.00/2.56)	
Tags (2.61/3.61)	Annotations (DC04) = 6.22/ 7.22	Tags (2.61 /3.61)	Annotations (DC04) =6.22/7.22
Hatch patterns (3.61/3.61)		Hatch patterns (3.61/3.61)	
Correct layering and grouping of objects (2.2/2.4)	Drawing Clarity and Presentation (DA01) = 9.8/ 12	Correct layering and grouping of objects (1.80 2.4)	Drawing Clarity and Presentation (DA01) = 9.4/12
Axes' labels (2.4 /2.4)		Axes' labels (2.4/2.4)	
Correct line type selection (1.4/2.4)		Correct line type selection (1.4/2.4)	
Correct line weight selection (1.4/2.4)		Correct line weight selection (1.4/2.4)	
Hatch accuracy and scale (2.4/2.4)		Hatch accuracy and scale (2.4/2.4)	
Accuracy of intersections (1.395/2.79)	Alignment of objects (DA02) = 7.19/ 11.16	Accuracy of intersections (0.79 /2.79)	Alignment of objects (DA02) = 4.975/11.16
Polylines used (1.395/2.79)		Polylines used (0.79 /2.79)	
Accuracy of spacing (2.40/2.79)		Accuracy of spacing (1.395/2.79)	
Correct symbols for windows and doors (2.00/2.79)		Correct symbols for windows and doors (2.00/2.79)	
Consistency of units and scaling (24.92/25.92)	Drawing Technical Precision (DA03) = 48.37/51.84	Consistency of units and scaling (24.92/25.92)	Drawing Technical Precision (DA03) = 47.84/51.84
Accuracy in measures (23.45/25.92)		Accuracy in measures (22.92/25.92)	
Drawing completeness (DC) + Drawing accuracy and quality (DA) = (22.21+65.36) = 87.57		Drawing completeness (DC) + Drawing accuracy and quality (DA) = (22.07+ 62.22) = 84.29	
4g: Task 3		**4h: Task 4**	
			
Points awarded for each indicator	**Points awarded for sub-criterion**	**Points awarded for each indicator**	**Points awarded for sub-criterion**
Axes (2.11/2.11)	Drawings (DC01) = 4.22/4.22	Construction Lines (4.225/4.225)	Drawings (DC01) = 4.225/4.225
Construction Lines (2.11/2.11)			
Drawing completed with layers (7.425/8.425)	Layer management (DC02) =.425/8.425	Drawing completed with layers (6.425/8.425)	Layer management (DC02) = 6.425/8.425
External dimensions (2.00/2.56)	Dimensions (DC03) = 3.56/5.12	External dimensions (1.56/2.56)	Dimensions (DC03)

Table 9. Evaluation of computer-based tasks based on the AHP evaluation framework, medium-performance participant (Source: Authors).

4e: Task 1		**4f: Task 2**	
Internal dimensions (1.56/2.56)		Internal dimensions (2.00/2.56)	= 3.56/5.12
Material definition (2.31/3.61)	Annotations (DC04) = 3.92/7.22	Tags (2.41/2.41)	Annotations (DC04) = 5.82/7.23
		Hatch patterns (2.00/2.41)	
Fixtures (1.61/3.61)		Material definition (1.41/2.41)	
Correct layering and grouping of objects (1.40/2.4)	Drawing Clarity and Presentation (DA01) = 7/12	Correct layering and grouping of objects (1.40/2.4)	Drawing Clarity and Presentation (DA01) = 7.2/12
Correct line type selection (1.40/2.4)		Correct line type selection (1.40/2.4)	
Correct line weight selection (1.40/2.4)		Correct line weight selection (1.40/2.4)	
Hatch accuracy and scale (1.4/2.4)		Hatch accuracy and scale (2.0/2.4)	
Materials' location (1.4/2.4)		Materials' location (1.0/2.4)	
Accuracy of intersections (1.24/2.79)	Alignment of objects (DA02) = 6.06/11.2	Accuracy of intersections (2.4 /3.69)	Alignment of objects (DA02) = 6.49/11.07
Polylines used (1.79/2.79)		Polylines used (2.4/3.69)	
Accuracy of spacing (1.79/2.79)		Accuracy of spacing (1.69/3.69)	
Correct placement of fixtures (1.24/2.79)			
Consistency of units and scaling (23.92/25.92)	Drawing Technical Precision (DA03) = 44.84/51.84	Consistency of units and scaling (21.92/25.92)	Drawing Technical Precision (DA03) = 37.84/51.84
Accuracy in measures (20.92/25.92)		Accuracy in measures (15.92/25.92)	
Drawing completeness (DC) + Drawing accuracy and quality (DA) = (19.13 + 57.9) = 77.03		Drawing completeness (DC) + Drawing accuracy and quality (DA) = (20.03+51.53) = 71.56	

Table 10. Evaluation of computer-based tasks based on the AHP evaluation framework, high-performance participant (Source: Authors).

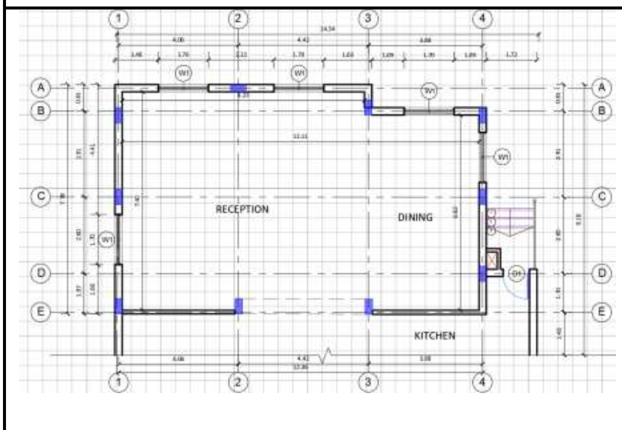
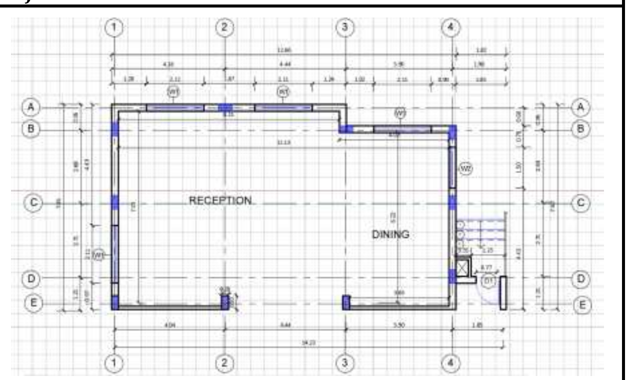
4i: Task 1		**4j: Task 2**	
			
Points awarded for each indicator	**Points awarded for sub-criterion**	**Points awarded for each indicator**	**Points awarded for sub-criterion**
Axes (0.60/0.60)	Drawings (DC01) = 4.225/4.225	Axes (0.60/0.60)	Drawings (DC01) = 4.225/4.225
Construction Lines (0.60/0.60)		Construction Lines (0.6/0.60)	
Columns (0.60/0.6)		Columns (0.60/0.60)	
Walls (0.60/0.60)		Walls (0.60/0.60)	
Windows (0.60/0.60)		Windows (0.60/0.60)	
Doors (0.6/0.60)		Doors (0.60/0.60)	
Stairs/steps (0.60/0.60)		Stairs/steps (0.60/0.60)	

Table 10. Evaluation of computer-based tasks based on the AHP evaluation framework, high-performance participant (Source: Authors).

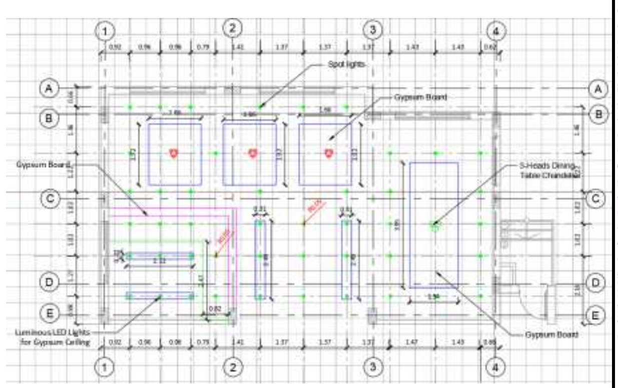
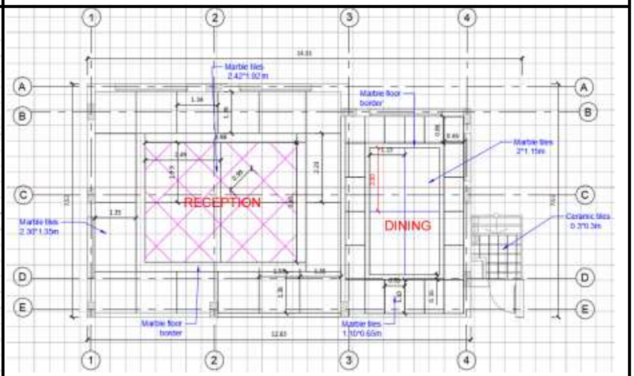
4i: Task 1		**4j: Task 2**	
Drawing completed with layers (8.425/8.425)	Layer management (DC02) = 8.425/8.425	Drawing completed with layers (8.425/ 8.425)	Layer management (DC02) = 8.425/8.425
External dimensions (2.56/2.56)	Dimensions (DC03) =5.12/5.12	External dimensions (2.56 /2.56)	Dimensions (DC03) = 5.12/5.12
Internal dimensions (2.56/2.56)		Internal dimensions (2.56/2.56)	
Tags (3.61/3.61)	Annotations (DC04) = 7.22/ 7.22	Tags (3.61 /3.61)	Annotations (DC04) = 7.22/7.22
Hatch patterns (3.61/3.61)		Hatch patterns (3.61/3.61)	
Correct layering and grouping of objects (2.4/2.4)	Drawing Clarity and Presentation (DA01) = 11/ 12	Correct layering and grouping of objects (2.4 2.4)	Drawing Clarity and Presentation (DA01) = 11/12
Axes' labels (2.4 /2.4)		Axes' labels (2.4/2.4)	
Correct line type selection (2.4/2.4)		Correct line type selection (2.4/2.4)	
Correct line weight selection (1.4/2.4)		Correct line weight selection (1.4/2.4)	
Hatch accuracy and scale (2.4/2.4)		Hatch accuracy and scale (2.4/2.4)	
Accuracy of intersections (1.395/2.79)	Alignment of objects (DA02) = 8.37/ 11.16	Accuracy of intersections (1.00 /2.79)	Alignment of objects (DA02) = 7.19/11.16
Polylines used (1.395/2.79)		Polylines used (1.00/2.79)	
Accuracy of spacing (2.79/2.79)		Accuracy of spacing (2.4/2.79)	
Correct symbols for windows and doors (2.79/2.79)		Correct symbols for windows and doors (2.79/2.79)	
Consistency of units and scaling (25.92/25.92)	Drawing Technical Precision (DA03) = 50.84/51.84	Consistency of units and scaling (25.92/25.92)	Drawing Technical Precision (DA03) = 49.84/51.84
Accuracy in measures (24.92/25.92)		Accuracy in measures (23.92/25.92)	
Drawing completeness (DC) + Drawing accuracy and quality (DA) = (25+70.21) = 95.21		Drawing completeness (DC) + Drawing accuracy and quality (DA) = (25 + 68.03) = 93.03	
4k: Task 3		**4l: Task 4**	
			
Points awarded for each indicator	**Points awarded for sub-criterion**	**Points awarded for each indicator**	**Points awarded for sub-criterion**
Axes (2.11/2.11)	Drawings (DC01) = 4.22/4.22	Construction Lines (4.225/4.225)	Drawings (DC01) = 4.225/4.225
Construction Lines (2.11/2.11)			
Drawing completed with layers (6.425/8.425)	Layer management (DC02) = 6.425/8.425	Drawing completed with layers (6.425/8.425)	Layer management (DC02) = 6.425/8.425
External dimensions (2.56/2.56)	Dimensions (DC03)	External dimensions (2.56/2.56)	Dimensions (DC03) = 5.12/5.12

Table 10. Evaluation of computer-based tasks based on the AHP evaluation framework, high-performance participant (Source: Authors).

<table>
<tr><th colspan="2">4i: Task 1</th></tr>
<tr><td>Internal dimensions (2.56/2.56)</td><td>= 5.12/5.12</td></tr>
<tr><td>Material definition (3.61/3.61)</td><td rowspan="2">Annotations (DC04) = 7.22/7.22</td></tr>
<tr><td>Fixtures (3.61/3.61)</td></tr>
<tr><td>Correct layering and grouping of objects (1.8/2.4)</td><td rowspan="5">Drawing Clarity and Presentation (DA01) = 9.8/12</td></tr>
<tr><td>Correct line type selection (2.4/2.4)</td></tr>
<tr><td>Correct line weight selection (1.40/2.4)</td></tr>
<tr><td>Hatch accuracy and scale (2.4/2.4)</td></tr>
<tr><td>Materials' location (1.8/2.4)</td></tr>
<tr><td>Accuracy of intersections (1.395/2.79)</td><td rowspan="4">Alignment of objects (DA02) = 7.98/11.2</td></tr>
<tr><td>Polylines used (1.395/2.79)</td></tr>
<tr><td>Accuracy of spacing (2.40/2.79)</td></tr>
<tr><td>Correct placement of fixtures (2.79/2.79)</td></tr>
<tr><td>Consistency of units and scaling (25.92/25.92)</td><td rowspan="2">Drawing Technical Precision (DA03) = 50.84/51.84</td></tr>
<tr><td>Accuracy in measures (24.92/25.92)</td></tr>
<tr><td colspan="2">Drawing completeness (DC) + Drawing accuracy and quality (DA) = (23 + 68.62) = 91.62</td></tr>
</table>

<table>
<tr><th colspan="2">4j: Task 2</th></tr>
<tr><td>Internal dimensions (2.56/2.56)</td><td></td></tr>
<tr><td>Tags (2.41/2.41)</td><td rowspan="3">Annotations (DC04) = 5.82/7.23</td></tr>
<tr><td>Hatch patterns (1.41/2.41)</td></tr>
<tr><td>Material definition (2.00/2.41)</td></tr>
<tr><td>Correct layering and grouping of objects (1.8/2.4)</td><td rowspan="5">Drawing Clarity and Presentation (DA01) = 8.6/12</td></tr>
<tr><td>Correct line type selection (1.4/2.4)</td></tr>
<tr><td>Correct line weight selection (1.4/2.4)</td></tr>
<tr><td>Hatch accuracy and scale (2.0/2.4)</td></tr>
<tr><td>Materials' location (2.0/2.4)</td></tr>
<tr><td>Accuracy of intersections (1.845 /3.69)</td><td rowspan="3">Alignment of objects (DA02) = 7.09/11.07</td></tr>
<tr><td>Polylines used (1.845/3.69)</td></tr>
<tr><td>Accuracy of spacing (3.4/3.69)</td></tr>
<tr><td>Consistency of units and scaling (25.92/25.92)</td><td rowspan="2">Drawing Technical Precision (DA03) = 50.84/51.84</td></tr>
<tr><td>Accuracy in measures (24.92/25.92)</td></tr>
<tr><td colspan="2">Drawing completeness (DC) + Drawing accuracy and quality (DA) = (21.59+66.53) = 88.12</td></tr>
</table>

This is evidenced by a larger relative change in scores for DC than for DA for each task. Therefore, the results support the validity and comparability of the proposed framework, as demonstrated through its application to sample drawings from three participants. However, these findings may not represent productivity patterns across the entire sample. Additionally, the main goal of this work is to illustrate how AHP can be used to establish an objective evaluation system.

5. Discussion

In this work, we demonstrate the potential of the Analytic Hierarchy Process (AHP) to establish a structured evaluation framework for objectively assessing architectural working drawings. This aims to address long-standing issues of subjectivity and inconsistency in their evaluation.

Historically, efforts to evaluate working drawings have mainly relied on criteria-based or standards-based models. For example, Elbellahy (2020) introduced a criteria-based evaluation framework for working drawings, emphasizing improvements in transparency, fairness, and reducing evaluator deviation. However, such models often assign weights arbitrarily or evenly across criteria without a formal method to determine their relative importance. Standards-based frameworks, as discussed by Górska (2011) and Simmons *et al.* (2012), emphasize compliance with technical regulations, graphical conventions, and international standards. While these standards ensure basic quality and clear communication, they are often checklist-oriented and do not explicitly prioritize criteria based on specific project goals or educational objectives.

Similarly, BIM-based evaluation methods, such as those outlined by Saavedra *et al.* (2025), aim to ensure the completeness and consistency of digital construction models. Although these methods utilize advanced technology to enhance data integration and automate clash detection, they typically require significant technical skills, specialized software, and substantial time investments. Furthermore, their use is generally limited to digital environments. In comparison, the AHP framework proposed here remains flexible for manual and digital formats, allowing broader application across different project phases, scales, and educational settings.

From an educational perspective, Harputlugil (2018) demonstrated that applying AHP in architectural studios yields measurable, comparable, and consistent evaluation results, thereby reducing the subjectivity and variability that often challenge architectural assessment processes. Additionally, Hatipoğlu *et al.* (2024) highlighted that student-centered AHP-based evaluations of architectural program outcomes improve the alignment between academic curricula and professional skills, emphasizing the value of participatory and structured assessment models.

However, the AHP-based framework has limitations, including its dependence on evaluator consistency and the time required to develop the hierarchy and weighting matrices. It inherently relies on the evaluators' consistency and expertise during the pairwise comparison process; discrepancies can create biases if not carefully managed. Furthermore, the initial creation of the hierarchy and weighting matrices requires significant time and effort, which can pose challenges in time-sensitive environments such as architectural studios or fast-paced professional offices.

A potential risk associated with the proposed framework is its possible misuse if applied without professional oversight, for example, through automation or delegation to untrained individuals. Such practices could compromise the integrity of the evaluation process and diminish the essential role of the architect's expert judgment. To address this concern, it is emphasized that the AHP framework is not intended as a stand-alone or fully automated procedure. Instead, it is designed as a structured decision-support mechanism that depends on the informed input of qualified professionals to ensure both validity and contextual relevance. The architect's role therefore remains indispensable in selecting appropriate criteria, interpreting results, and integrating broader design considerations contextual, cultural, and qualitative that cannot be captured by numerical models alone.

Despite these limitations, the benefits of adopting the AHP framework are significant. It enhances transparency, reduces subjectivity, and offers flexibility to tailor evaluation processes to the specific needs of different projects or educational settings. Understanding the priorities and preferences of experts and business owners is not only crucial for clarifying and assessing outputs but also for helping young architects manage their workloads effectively, especially when working within tight deadlines, which is often the case.

6. Conclusions

This study proposed and tested an AHP-based framework for evaluating working drawings, demonstrating its capacity to prioritize accuracy, quality, and completeness in a transparent and systematic manner. The contribution of this work lies in bridging subjective design evaluation with an objective, quantifiable approach, thereby strengthening decision-making while preserving the creative nature of architectural work.

Beyond its experimental context, the framework contributes to both practice and education. For practice, it provides an evidence-based approach to evaluating drawing outputs, which can support quality control, performance monitoring, and productivity assessments in professional environments. For education, it provides a structured tool for guiding architectural training, making explicit which aspects of drawing quality are most critical and how they should be prioritized.

The framework was preliminarily tested with three participants, as detailed in Section 4.2, thereby demonstrating its potential for broader application. Future research should extend testing to larger and more complex tasks and explore integration into international practice to further validate its applicability and acceptance among both architects and technical experts.
An additional limitation is the absence of a survey of practicing designers from different countries to capture their perspectives on the AHP method and their willingness to integrate it into the design process. While this fell beyond the scope of the current research, it represents an important direction for future work to assess the method's international relevance and professional acceptance.

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