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A Delphi and Importance–Performance Analysis Framework for Fire Safety Competencies of Architects and Fire Safety Engineering Consultants in the UAE

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Abstract

Fire safety in high-rise buildings represents a critical challenge in the United Arab Emirates (UAE), where intensive urbanization, extreme climatic conditions, and multilayered regulatory frameworks impose unique competency demands on architects and Fire Safety Engineering (FSE) consultants. Despite this, no empirically validated competency framework exists that simultaneously addresses both professional groups and is tailored to the specificities of the UAE context. This study aimed to construct and empirically validate such a framework. A three-phase sequential exploratory mixed-method design was employed. In the first phase, a systematic literature review yielded a preliminary set of 69 competency indicators organized within a Knowledge, Skills and Attitudes (KSA) structure. In the second phase, a three-round Delphi technique with an expert panel of 18 specialists validated the set to 62 final indicators. In the third phase, importance–performance analysis (IPA) was conducted on a sample of 250 professionals actively engaged in fire safety projects across four UAE. IPA identified 16 priority competency gaps, most pronounced in digital transformation (BIM, CFD, AI; gap = 1.23), proactive client advisory competencies (gap = 1.21), and regulatory navigation and Civil Defence coordination (gap = 1.00). A counterintuitive finding emerged whereby architects systematically rated competencies higher than FSE consultants across all dimensions (all $p < 0.05$). Psychometric validation confirmed excellent instrument reliability (Cronbach's Alpha > 0.95) and a theoretically consistent three-factor KSA structure explaining 70.06% of variance. The developed framework of 62 empirically validated indicators represents the first competency model of its kind for architects and FSE consultants in the Gulf Cooperation Council (GCC) region. Its findings provide a direct empirical basis for curriculum reform, Continuing Professional Development (CPD) programmes, and professional licencing standards in the UAE and across the GCC region. The study makes three original contributions: the first empirically validated UAE-specific competency framework for these professional groups; a methodological combination of Delphi, IPA, EFA, Mann–Whitney, and Kruskal–Wallis not previously applied in fire safety competency research; and empirical confirmation that 74% of indicators required original development or adaptation, demonstrating the limitations of generic international competency models in the UAE context.

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1. Introduction

Fire safety in buildings represents one of the central issues in contemporary urban development, and its significance becomes particularly evident in environments characterized by intensive high-rise construction, dynamic regulatory development, and pronounced professional heterogeneity. At the global level, building fires constitute a major safety and economic problem, causing tens of thousands of fatalities and material damages amounting to hundreds of billions of dollars annually [1]. Numerous studies indicate that more than 70% of the factors influencing fire outcomes are determined at the design stage, which clearly confirms that the professional competencies of architects and FSE consultants play a significant role in ensuring the safety of building occupants [2]. Despite this, the development of empirically grounded competency frameworks tailored to specific professional and regulatory contexts remains an underexplored area in the scientific literature, particularly outside the Western European and North American context [3].

The United Arab Emirates (UAE) represent a particularly complex and research-relevant context for studying fire safety competencies. Over the past four decades, the UAE has undergone one of the most intensive urbanization processes in modern history—cities such as Dubai and Abu Dhabi have been transformed into global metropolises with more than 200 buildings exceeding 150 m in height [4]. This building typology, encompassing high-rise residential towers, complex mixed-use developments, and shopping centres with capacities of hundreds of thousands of visitors, places competency demands that far exceed what generic international standards can address. An additional layer of complexity is introduced by extreme climatic conditions—temperatures exceeding 45 °C during summer months, sandstorms that disrupt the operation of detection systems, and high coastal humidity that accelerates the corrosion of fire protection system components—all of which require specialized expertise that is largely absent from standard international educational programmes [4]. Finally, the distinctly multicultural composition of the professional community, in which more than 88% of the workforce consists of foreign nationals from over one hundred different countries and educational backgrounds, further complicates the alignment of professional standards, communication practices, and fire safety competency requirements [5].

The UAE regulatory framework for fire protection further amplifies this complexity. Architects and FSE consultants are simultaneously required in practice to apply the Fire and Life Safety Code of Practice (FLSC), the Abu Dhabi International Building Code (ADIBC), and Civil Defence approval procedures that vary across individual emirates, alongside the international standards of the National Fire Protection Association (NFPA) series and British standards BS 9999 and BS 5839 [6]. Documented fire incidents in the UAE—the Address Downtown Dubai fire and the fires at The Torch Tower Dubai, both involving rapid vertical fire spread along facade systems—indicate that formal regulatory compliance alone is not a sufficient guarantee of fire safety, and that the professional competencies of designers are decisive for safety outcomes [4]. At the same time, the Grenfell Tower fire in London (2017), in which 72 people perished due to the use of combustible Aluminum Composite Material (ACM) facade panels, had a direct impact on regulatory development in the UAE through the introduction of stricter requirements for facade materials and designer competencies [3].

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The theoretical framework for studying professional competencies in fire safety is grounded in two interrelated and complementary conceptual approaches. Competency-Based Education (CBE) theory holds that competencies are measurable learning outcomes that must be clearly rooted in real professional contexts [7,8]. The Knowledge, Skills and Attitudes (KSA) professional competency paradigm, established in the seminal works of McClelland [9], Boyatzis [10], and Spencer and Spencer [11], breaks competencies down into interrelated knowledge, skills, and attitudes dimensions, each of which requires specific approaches to learning and professional development. The application of these theoretical frameworks in engineering and architectural professions is documented in the literature through the development of competency frameworks for architectural and engineering professions; however, these are primarily grounded in western regulatory contexts and do not reflect the specificities of fire safety practice in the UAE [3]. This disconnect is particularly consequential in the UAE context, where high-rise building density exceeding 200 structures above 150 m, extreme climatic conditions including temperatures above 45 °C and frequent sandstorms [4], and a workforce comprising professionals from over one hundred nationalities [5] collectively generate competency demands that generic Western frameworks are structurally incapable of addressing. Existing competency research in fire safety engineering has not examined how these contextual factors—individually or in combination—reshape the knowledge, skills, and attitudinal requirements of design professionals, leaving a critical void between what the international literature prescribes and what UAE professional practice demands [3].

Two methodological approaches stand out in the literature for the empirical construction and validation of competency frameworks and are used in an integrated manner in the present study. The Delphi technique, methodologically developed in the works of Delbecq et al. and Linstone and Turoff, represents a structured approach to achieving expert consensus through iterative rounds of anonymous surveying, and is particularly suitable for complex professional domains in which no unambiguous empirical answer exists [12–14]. Importance–performance analysis (IPA), originally developed by Martilla and James, is a two-dimensional analytical method that positions competencies according to perceived importance and performance, enabling the identification of priority areas for intervention [15]. Shyr and colleagues demonstrated the applicability of a combined Delphi-IPA approach in the fire safety context through the development of a competency framework for fire suppression system technicians in Taiwan, thereby establishing the methodological foundation for the present study [16].

Despite the theoretical and methodological achievements outlined above, a systematic literature review reveals a significant gap in existing knowledge. No available competency framework simultaneously meets the criteria of being directed at architects and FSE consultants as the primary agents responsible for integrating fire safety requirements into design practice, being adapted to the regulatory, climatic, and multicultural specificities of the UAE context, being developed through a combination of methodologically rigorous Delphi validation and IPA, and reflecting the contemporary UAE regulatory framework in the aftermath of relevant fire incidents. Studies that explicitly address the UAE fire safety context generally identify systemic challenges but do not develop empirically validated competency models [4]. Studies from the GCC region that have addressed related topics indicate a growing need for contextualized approaches, but without a focus on competency frameworks for design professions [3]. This gap is particularly critical given that UAE fire safety practice operates within a regulatory environment that is simultaneously more complex, more multicultural, and more climatically demanding than any context in which existing competency frameworks have been developed and validated—rendering direct application of available models not merely suboptimal, but potentially inadequate for

ensuring the safety of building occupants. The present study directly addresses this gap by constructing the first competency framework that simultaneously targets both architects and FSE consultants, integrates UAE-specific regulatory, climatic, and multicultural requirements, and is empirically validated through a combined Delphi-IPA methodology.

Considering the identified gap, the present study aims to construct and empirically validate a competency framework that defines the knowledge, skills, and attitudes necessary for architects and FSE consultants to operate responsibly and effectively in the field of fire safety in the UAE. The specific contributions of the study are fourfold. First, the study seeks to provide a competency framework for these professional groups in the GCC region that integrates the regulatory, climatic, and multicultural specificities of the UAE context. Second, the combination of the Delphi technique, IPA, Exploratory Factor Analysis (EFA), the Mann–Whitney U test, and the Kruskal–Wallis test has not been applied in this form in any previous fire safety competency study. Third, 74% of the final indicators are original or adapted relative to the baseline study by Shyr et al. (2021) [16], which empirically confirms that international competency models cannot be mechanically applied to UAE fire safety practice without significant local adaptation. Fourth, the study identifies the counterintuitive finding that architects systematically perceive competencies as more important than FSE consultants do, which opens new theoretical questions about professional identity and self-assessment in specialized engineering domains.

2. Materials and Methods

2.1. Research Design

The present study is grounded in a Sequential Exploratory Mixed Methods Design, which integrates a systematic literature review and iterative expert consensus validation through the Delphi technique with quantitative empirical measurement through IPA into a coherent three-phase research structure [17,18]. This design was selected because the nature of the research problem requires the complementary application of both methodological approaches—identifying and validating competency indicators relies on expert knowledge and theoretical literature synthesis that is not accessible through exclusively quantitative methods, whereas measuring competency gaps and comparative differences demands statistical analysis on a representative sample that exceeds the reach of purely exploratory approaches [17].

The study was conducted through three interrelated phases. In the first phase, a preliminary set of 69 competency indicators was constructed through a systematic literature review and organized within a three-tier hierarchical structure grounded in the KSA paradigm. In the second phase, a three-round Delphi technique with an expert panel of 18 specialists reduced and validated the preliminary set to 62 final indicators. In the third phase, IPA conducted on a sample of 250 professionals identified priority competency gaps and enabled comparative analyses by professional role, experience, and educational background.

2.2. Phase 1—Literature Review and Construction of the Preliminary Indicator Set

The first phase of the study involved a systematic review of relevant scientific and professional literature with the aim of constructing a preliminary set of competency indicators. The literature search was conducted in January 2025 across four electronic databases—Scopus, Web of Science, Education Resources Information Center (ERIC), and Google Scholar. The search terms comprised combinations of the following keywords: fire safety competency, fire protection engineering education, competency-based education, architect fire safety, UAE fire regulations, Delphi competency framework, and importance–performance analysis fire safety.

Inclusion criteria encompassed studies published between 2000 and 2025, written in English, and addressing competencies in fire safety, architectural and engineering education, or the development of competency frameworks through the Delphi technique or IPA. Studies dealing exclusively with technical aspects of fire protection systems without relevance to professional competencies were excluded, as were non-peer-reviewed publications.

The literature synthesis led to the identification of the primary methodological foundation of the study—the work of Shyr and colleagues, which demonstrated the applicability of a combined Delphi-IPA approach for constructing and validating competency indicators in fire safety. Their original framework was adapted and substantially expanded to reflect the professional and regulatory specificities of the UAE context. Of the 69 preliminary indicators constructed, 74% were either originally developed or adapted for the UAE context, while the remaining 26% represent direct adaptations from the baseline study.

The preliminary set of 69 indicators was organized within a three-tier hierarchical structure comprising three dimensions (knowledge, skills, and attitudes), 13 sub-dimensions, and 69 detailed indicators. The knowledge dimension encompassed five sub-dimensions: FSE regulations and standards, fire protection systems and equipment, UAE climatic specificities, fire science and evacuation, and auxiliary knowledge. The skills dimensions comprised four sub-dimensions: fire safety integration into design, Performance-Based Design (PBD) and simulations, coordination with Civil Defence, and project team coordination. The attitudes dimensions included four sub-dimensions: legality and ethics, integrity and accountability, commitment and teamwork, and professional advancement and learning.

2.3. Phase 2—Delphi Technique

2.3.1. Expert Panel Composition

An expert panel of 18 specialists was assembled for the Delphi process, distributed across four professional groups: six FSE consultants with active practice in the UAE, five architects with documented experience in fire safety design, four Civil Defence inspectors from different emirates, and three academics with a research focus on fire safety or competency-based education.

The panel size is consistent with methodological recommendations, suggesting that a panel of 15 to 30 experts provides sufficient diversity of perspectives while remaining manageable for the consensus process [12]. All panel members satisfied the following inclusion criteria: a minimum of ten years of professional experience in fire safety within the UAE context; direct involvement in UAE Civil Defence approval procedures; active engagement with UAE-specific regulatory frameworks including the FLSC and ADIBC; and a demonstrable track record of fire safety design, inspection, or research in one or more UAE. In terms of professional backgrounds, the six FSE consultants held active UAE Engineers Register licences and had direct experience with performance-based design submissions to Civil Defence; the five architects had documented involvement in high-rise fire safety design projects in Abu Dhabi or Dubai; the four Civil Defence inspectors were active employees of emirate-level Civil Defence directorates; and the three academics held positions at UAE-based universities with a research focus on fire safety engineering or competency-based education. Expert recruitment was conducted through purposive sampling based on professional reputation, published work, and recommendations from professional associations, including the Society of Fire Protection Engineers UAE Chapter and the Emirates Society of Engineers.

2.3.2. Instrument and Validation Criteria

The Delphi instrument was developed as a structured questionnaire in which experts rated 69 preliminary competency indicators. Assessments were made using a five-point Likert relevance scale, where 1 indicated "completely irrelevant" and 5 indicated "extremely relevant."

Validation criteria were applied in accordance with standard Delphi methodology [12,13]. Indicators achieving a mean $M \geq 3.5$ with a standard deviation $SD \leq 1.0$ were retained for the subsequent evaluation round. Indicators with $SD \leq 0.5$ were considered to have reached consensus and were excluded from further rating. Conversely, indicators that did not meet the $M \geq 3.5$ threshold were removed from further consideration.

Following each round, participants received aggregated statistical results from the previous round alongside their individual responses. This feedback enabled informed revision of judgments and gradual convergence toward consensus—a standard procedure in Delphi research [13,14].

2.3.3. Delphi Process Overview

The Delphi process was conducted across three iterative rounds between January and May 2025. In Round 1 (January 2025), experts evaluated all 69 preliminary competency indicators. Applying the predefined validation criteria, seven indicators were eliminated due to insufficient relevance ratings (1.1.6, 1.2.1, 1.5.1, 1.5.4, 2.3.1, 2.3.2, 2.3.3). Simultaneously, three indicators achieved full expert agreement in the first round, with SD = 0.000 (3.1.3, 3.1.5, 3.3.1), reflecting unanimous consensus regarding their professional relevance. Following Round 1, 62 indicators advanced to the next phase.

In Round 2 (April 2025), 30 indicators reached consensus criteria ($SD \leq 0.5$), while the remaining 32 were retained for final evaluation. In Round 3 (May 2025), all remaining indicators likewise achieved consensus, yielding a final validated set of 62 competency indicators. A summary of the complete Delphi process is presented in Table 1.

Table 1. Summary of the Delphi validation process.

Round	Period	Indicators Evaluated	Eliminated	Consensus Reached ($SD \leq 0.5$)	Passed to Next Round
Round 1	January 2025	69	7	3 (SD = 0.000)	62
Round 2	April 2025	62	0	30	32
Round 3	May 2025	32	0	32	-
Total	January–May 2025	69	7	65 evaluations/62 validated	-

Note: Indicators eliminated in Round 1: 1.1.6, 1.2.1, 1.5.1, 1.5.4, 2.3.1, 2.3.2, 2.3.3. Indicators reaching full consensus in Round 1 (SD = 0.000): 3.1.3, 3.1.5, 3.3.1. Total consensus evaluations across three rounds: 3 + 30 + 32 = 65; final validated competency framework comprises 62 indicators, excluding the 7 indicators eliminated in Round 1.

2.4. Phase 3—Importance–Performance Analysis

2.4.1. Sample Characteristics

The third phase of the study was conducted between June and September 2025 on a sample of 250 professionals actively engaged in fire safety projects in the UAE. The sample comprised architects with documented fire safety experience and FSE consultants from all four major emirates—Abu Dhabi, Dubai, Sharjah, and Ras Al Khaimah. A detailed demographic profile of the sample is presented in Table 2.

Table 2. Demographic profile of the sample (N = 250).

Characteristic	Category	n	%
Professional role	Architect	139	55.6
	FSE Consultant [1]	111	44.4
Years of experience	<5 years	49	19.6
	5–10 years	58	23.2
	11–20 years	81	32.4
	>20 years	62	24.8
Emirate	Abu Dhabi	91	36.4
	Dubai	81	32.4
	Sharjah	46	18.4
	Ras Al Khaimah	32	12.8
Education level	Bachelor	77	30.8
	Master	118	47.2
	PhD	55	22.0
Total		250	100.0

[1] Note: FSE = Fire Safety Engineering. Percentages may not sum to exactly 100.0 due to rounding.

2.4.2. Instrument and Data Collection Procedure

The IPA instrument was constructed as a structured questionnaire encompassing the 62 competency indicators validated during the Delphi phase. Each indicator was rated on two separate five-point Likert scales: an importance scale (1 = completely unimportant, 5 = extremely important) and a performance scale (1 = extremely low performance, 5 = extremely high performance). This dual-scale approach aligns with the original IPA methodology developed by Martilla and James [15], as well as its application in the study by Shyr and colleagues [16].

The questionnaire was distributed electronically through professional networks and associations in the UAE, including the Society of Fire Protection Engineers UAE Chapter, the Emirates Society of Engineers, and the Dubai Municipality approved consultants register. A five-point Likert scale was selected for both the importance and performance dimensions based on three considerations: its widespread application in IPA-based competency research, including the methodological baseline study by Shyr and colleagues [16]; its demonstrated sensitivity in capturing meaningful gradations in professional judgments without generating response fatigue associated with wider scales; and its established psychometric properties in competency assessment contexts, as documented in the measurement literature [19]. Prior to official distribution, the instrument was pilot tested on a purposively selected sample of five professionals—two architects, two FSE consultants, and one Civil Defence inspector—none of whom participated in the main study. The pilot testing process focused on three aspects: clarity and comprehensibility of indicator formulations, appropriateness of the dual-scale format, and estimated completion time. Based on pilot feedback, three categories of revisions were made: terminological adjustments to four indicators whose phrasing was identified as ambiguous in the UAE professional context; linguistic simplification of two indicators containing overly technical vocabulary that could be misinterpreted by non-native English speakers; and a structural reorganization of the questionnaire introduction to more clearly explain the distinction between the importance and performance rating scales.

2.4.3. IPA Matrix and Priority Identification

The IPA matrix was constructed by positioning each competency indicator within a two-dimensional grid according to mean importance scores (x-axis) and mean performance scores (y-axis), with axis intersection points determined by the global mean values for each dimension—specifically, the mean performance score and mean importance score across

all indicators within that dimension [15]. This approach yielded four analytical distinct quadrants with explicit definitional boundaries.

Quadrant I (high importance–high performance; both scores above dimension mean) encompasses competencies representing existing professional strengths that should be actively maintained and reinforced through continued professional development. Quadrant II (high importance–low performance; importance above mean, performance below mean) identifies competencies requiring priority improvement and constitutes the primary target for educational and professional intervention. Quadrant III (low importance–low performance; both scores below dimension mean) encompasses competencies currently perceived as less critical to professional practice; while these do not require immediate intervention, they should not be disregarded entirely, as shifts in regulatory requirements or technological developments may elevate their importance over time, warranting periodic reassessment within a dynamic competency management framework. Quadrant IV (low importance–high performance; importance below mean, performance above mean) captures competencies into which more resources may currently be invested than is professionally warranted, suggesting a potential reallocation of educational effort toward higher-priority areas.

Within the present study, particular attention was directed toward indicators positioned in Quadrant II, as these represent priority competency gaps with the greatest significance for advancing fire safety professional practice in the UAE.

2.5. Statistical Analysis

Beyond IPA, four groups of additional statistical analyses were conducted to comprehensively assess the psychometric properties of the instrument and examine comparative differences in competency perception across demographic and professional characteristics of the participants.

The first group addressed internal consistency, assessed through Cronbach's Alpha coefficients calculated separately for each of the three dimensions (knowledge, skills, and attitudes) on both scales (importance and performance), yielding six internal consistency values in total. By the widely accepted criterion, Cronbach's Alpha values above 0.70 are considered acceptable, while values above 0.90 indicate excellent internal consistency [19].

The second group comprised EFA conducted separately for both scales, with the aim of verifying the alignment between the empirically derived factor structure and the theoretically postulated three-dimensional KSA competency structure. Prior to factor extraction, sampling adequacy was assessed using the Kaiser–Meyer–Olkin (KMO) test and Bartlett's test of sphericity [20], confirming the suitability of the data for multivariate analysis. Principal Axis Factoring was employed as the extraction method, with oblimin rotation applied to achieve a clearer and more interpretable factor structure.

The third group involved Pearson correlation analysis of inter-dimensional relationships, conducted separately for the importance and performance scales, to determine the degree of association among the knowledge, skills, and attitudes dimensions within the KSA competency model.

The fourth group consisted of comparative non-parametric tests. The Mann–Whitney U test was used to examine differences in competency perception between architects and FSE consultants, given that the data distribution did not satisfy the normality assumption required for parametric testing [21]. The Kruskal–Wallis test was applied to analyze differences by years of professional experience (four categories) and level of formal education (three categories).

All statistical analyses were performed using IBM SPSS Statistics, version 26 (IBM Corp., Armonk, NY, USA), with the significance level set at $p < 0.05$.

3. Results

3.1. Delphi Results and Final Competency Framework

The three-round Delphi process yielded a final competency framework comprising 62 validated indicators organized across three core dimensions and 13 sub-dimensions.

The knowledge dimension contains 23 indicators distributed across five sub-dimensions—UAE regulations and standards (six indicators), fire protection systems and equipment (five indicators), UAE climatic specificities (four indicators), fire science and evacuation (five indicators), and auxiliary knowledge (three indicators). The skills dimension encompasses 19 indicators structured across four sub-dimensions—fire safety integration into design (six indicators), PBD and simulations (four indicators), coordination with Civil Defence (four indicators), and project team coordination (five indicators). The attitudes dimension comprises 20 indicators organized across four sub-dimensions—legality and ethics (five indicators), integrity and accountability (five indicators), commitment and teamwork (five indicators), and professional advancement and learning (five indicators). The final competency framework is presented in Table 3.

Table 3. Final validated competency framework (62 indicators with M and SD from final Delphi round).

Code	Competency Indicator	M	SD	Round [1]
Dimension 1: Knowledge (23 indicators)				
1.1. UAE Regulations and Standards				
1.1.1.	Knowledge of UAE Civil Defence Law and federal fire protection legislation	4.83	0.383	K2
1.1.2.	Knowledge of UAE Fire and Life Safety Code of Practice (FLSC)	4.94	0.236	K2
1.1.3.	Knowledge of Abu Dhabi International Building Code (ADIBC)	4.83	0.383	K3
1.1.4.	Understanding of Civil Defence NOC approval procedure	4.83	0.383	K3
1.1.5.	Knowledge of NFPA standards applied in UAE (NFPA 1, 13, 72, 101)	4.83	0.383	K3
1.1.7.	Understanding of project approval stages: concept, detailed, construction, final certification	4.39	0.502	K2
1.2. Fire Protection Systems and Equipment				
1.2.2.	Knowledge of gaseous suppression systems (FM200, CO_2, Novec) for data centres	4.83	0.383	K3
1.2.3.	Knowledge of fire alarm, detection and voice evacuation systems (EVAC)	4.72	0.461	K2
1.2.4.	Knowledge of refuge floor and evacuation lift requirements in UAE high-rise buildings	4.78	0.428	K3
1.2.5.	Knowledge of Civil Defence vehicle access requirements and helipad provisions	4.83	0.383	K3
1.2.6.	Knowledge of facade material regulation and combustibility classification (ACM panels)	4.78	0.428	K3
1.3. UAE Climate Specificities				
1.3.1.	Understanding the impact of extreme temperatures (up to 50 °C) on fire protection systems	4.67	0.485	K2
1.3.2.	Knowledge of sandstorm effects on fire detection systems	4.78	0.428	K3
1.3.3.	Understanding the impact of high humidity in coastal emirates on fire system corrosion	4.89	0.323	K3
1.3.4.	Knowledge of lessons learned from UAE fire incidents (Address Hotel 2016, Torch Tower 2015/2017)	4.67	0.485	K2

Table 3. *Cont.*

Code	Competency Indicator	M	SD	Round [1]
1.4. Fire Science and Evacuation				
1.4.1.	Understanding fire development dynamics, flashover and smoke behaviour in enclosed spaces	4.72	0.461	K2
1.4.2.	Knowledge of evacuation dynamics fundamentals and egress calculations	4.83	0.383	K3
1.4.3.	Understanding of cultural factors affecting evacuation behaviour in the UAE context	4.78	0.428	K3
1.4.4.	Knowledge of people of determination needs—UAE terminology and legal requirements	4.83	0.383	K3
1.4.5.	Knowledge of performance-based design (PBD) methodology and its application in UAE	4.83	0.383	K3
1.5. Auxiliary Knowledge				
1.5.2.	Knowledge of CFD fire simulation software tools (FDS, Pyrosim)	4.78	0.428	K3
1.5.3.	Knowledge of egress simulation software (Pathfinder)	4.78	0.428	K3
1.5.5.	Knowledge of UAE FLSC and NFPA technical vocabulary in English	4.83	0.383	K3
Dimension 2: Skills (19 indicators)				
2.1. Integration of Fire Protection into Architectural Design				
2.1.1.	Producing a Fire Strategy Report from the concept design stage	4.78	0.428	K2
2.1.2.	Defining fire compartments and evacuation routes at early design stage	4.83	0.383	K2
2.1.3.	Dimensioning staircases, evacuation corridors and refuge floors per UAE FLSC	4.83	0.383	K2
2.1.4.	Integrating sprinkler systems and fire protection equipment into architectural drawings	4.83	0.383	K3
2.1.5.	Coordinating safety markings and evacuation signage within the project	4.83	0.383	K3
2.1.6.	Managing conflicts between esthetic requirements and fire protection requirements	4.72	0.461	K2
2.2. Performance-Based Design and Fire Simulation Skills				
2.2.1.	Assessing when PBD is necessary or advisable in the UAE context	4.78	0.428	K3
2.2.2.	Interpreting CFD fire simulation results and applying them to the design	4.78	0.428	K3
2.2.3.	Interpreting egress simulation results and applying them to the design	4.78	0.428	K3
2.2.4.	Presenting PBD solutions and documentation to Civil Defence	4.83	0.383	K3
2.4. Coordination with Civil Defence and Regulatory Authorities				
2.4.1.	Preparing submittal packages and documentation for Civil Defence NOC applications	4.83	0.383	K3
2.4.2.	Presenting fire strategy to Civil Defence inspectors and responding to technical comments	4.78	0.428	K3
2.4.3.	Monitoring UAE regulatory changes and timely adaptation of the design	4.61	0.514	K2
2.4.4.	Coordinating Civil Defence final inspection and obtaining completion certificate	4.83	0.383	K3
2.5. Project Team and Consultant Coordination Skills				
2.5.1.	Communicating fire protection requirements to the MEP team	4.89	0.323	K2

Table 3. *Cont.*

Code	Competency Indicator	M	SD	Round [1]
2.5.2.	Coordinating with FSE consultant—defining scope and verifying deliverables	4.78	0.428	K3
2.5.3.	Coordinating with facade consultants on fire protection aspects of facade systems	4.67	0.461	K3
2.5.4.	Briefing clients on fire protection implications of architectural decisions	4.78	0.428	K3
2.5.5.	Reviewing fire protection system shop drawings and managing on-site changes	4.67	0.485	K2
Dimension 3: Attitudes (20 indicators)				
3.1. Lawfulness and Professional Ethics				
3.1.1.	Refusing compromises that undermine fire protection requirements regardless of pressure	4.78	0.428	K2
3.1.2.	Documenting professional reservations and disagreements with client decisions	4.67	0.485	K2
3.1.3.	Adherence to UAE FLSC and applicable standards at all project stages	5.00	0.000	K1
3.1.4.	Non-disclosure of confidential project information and data	4.72	0.461	K2
3.1.5.	Conducting business without offering or accepting bribes or corruption	5.00	0.000	K1
3.2. Honesty and Accountability				
3.2.1.	Accurate and impartial reporting of fire protection analysis and simulation results	4.78	0.428	K2
3.2.2.	Ensuring fire protection design quality without cutting corners	4.94	0.236	K2
3.2.3.	Transparent communication of fire protection solution limitations and risks	4.78	0.428	K3
3.2.4.	Fulfilling contractual obligations related to fire protection documentation	4.72	0.461	K2
3.2.5.	Delivering complete O&M documentation and supporting facility management handover	4.67	0.461	K3
3.3. Dedication and Teamwork				
3.3.1.	Diligent and responsible approach to fire protection aspects from early to final stage	5.00	0.000	K1
3.3.2.	Effective communication within a multicultural project team	4.72	0.461	K2
3.3.3.	Cooperativeness and respect for different professional standards in multicultural teams	4.67	0.461	K2
3.3.4.	Crisis management and fire protection decision-making under deadline pressure	4.61	0.502	K2
3.3.5.	Advocating fire-safe solutions to the client as a proactive advisor	4.78	0.428	K2
3.4. Advancement and Continuous Learning				
3.4.1.	Actively monitoring amendments to UAE FLSC and relevant international standards	4.67	0.461	K2
3.4.2.	Participation in professional organizations relevant to UAE (RIBA Gulf, SFPE UAE Chapter)	4.67	0.461	K3
3.4.3.	Adopting new digital tools—BIM, CFD simulations, AI in fire analysis	4.67	0.461	K3
3.4.4.	Applying lessons learned from UAE fire incidents to current and future projects	4.83	0.383	K2
3.4.5.	Viewing fire-safe design as an architectural value, not merely a regulatory obligation	4.72	0.461	K2

[1] Note: M = mean score from final Delphi round; SD = standard deviation from final Delphi round; K1 = consensus reached in Round 1; K2 = consensus reached in Round 2; K3 = consensus reached in Round 3. Consensus criteria: $M \geq 3.5$, $SD \leq 1.0$ (retention); $SD \leq 0.5$ (consensus). Indicators 3.1.3, 3.1.5 and 3.3.1 achieved full consensus (SD = 0.000) in Round 1.

3.2. IPA Results by Dimension

IPA conducted on a sample of 250 professionals revealed a systematic gap between perceived competency importance and assessed performance levels across all KSA dimensions. Participants consistently rated competencies as more important than they rated their own—or their profession's—performance in applying them. Mean importance and performance values for each of the three dimensions are presented in Table 4.

Table 4. IPA results by competency dimension.

Dimension	M Performance	M Importance	Gap (I-P) [1]
Knowledge	3.57	4.37	0.80
Skills	3.58	4.42	0.84
Attitudes	3.70	4.51	0.81

[1] Note: M = mean value; Gap = Importance minus Performance. Higher values indicate greater priority for improvement.

The knowledge dimension yielded a mean performance of M = 3.57 and a mean importance of M = 4.37, producing an importance–performance gap of 0.80 points. The skills dimension recorded the largest mean gap across all KSA dimensions: mean performance was M = 3.58 against a mean importance of M = 4.42, resulting in a gap of 0.84 points. The attitudes dimension achieved the highest mean values for both performance (M = 3.70) and importance (M = 4.51), with a gap of 0.81 points between the two ratings. The negative gap observed across all dimensions reflects a consistent tendency within the professional community to perceive existing competencies as insufficiently developed relative to the demands of contemporary fire safety practice.

Positioning competency indicators within the IPA matrix enabled the identification of 16 indicators in Quadrant II (high importance–low performance), representing priority competency gaps that warrant targeted educational and professional interventions. Of the 16 identified priorities, three belong to the knowledge dimension, six to the skills dimension, and seven to the attitudes dimension. A detailed overview of all 16 priority indicators—including mean performance and importance values and the magnitude of each competency gap—is presented in Table 5, while the positions of all indicators within the IPA matrix are illustrated in Figures 1–3.

Table 5. Priority competency gaps—Quadrant II indicators (high importance, low performance).

Code	Competency Indicator	M Performance	M Importance	Gap [1]
Knowledge (3 indicators)				
1.3.3.	Understanding the impact of high humidity in coastal emirates on fire system corrosion	3.53	4.56	1.03
1.5.5.	Knowledge of UAE FLSC and NFPA technical vocabulary in English	3.41	4.40	0.99
1.2.6.	Knowledge of facade material regulation and combustibility classification (ACM panels)	3.50	4.43	0.93
Skills (6 indicators)				
2.5.4.	Briefing clients on fire protection implications of architectural decisions	3.26	4.45	1.19
2.4.3.	Monitoring UAE regulatory changes and timely adaptation of design	3.52	4.52	1.00
2.4.4.	Coordinating Civil Defence final inspection and obtaining completion certificate	3.46	4.46	1.00

Table 5. *Cont.*

Code	Competency Indicator	M Performance	M Importance	Gap [1]
2.2.4.	Presenting PBD solutions and documentation to Civil Defence	3.54	4.52	0.98
2.1.3.	Dimensioning staircases, evacuation corridors and refuge floors per UAE FLSC	3.45	4.42	0.97
2.2.2.	Interpreting CFD fire simulation results and applying them to design	3.55	4.42	0.87
Attitudes (7 indicators)				
3.4.3.	Adopting new digital tools—BIM, CFD simulations, AI in fire analysis	3.41	4.64	1.23
3.3.5.	Advocating fire-safe solutions to the client as a proactive advisor	3.57	4.78	1.21
3.4.4.	Applying lessons learned from UAE fire incidents to current and future projects	3.67	4.74	1.07
3.3.3.	Cooperativeness and respect for different professional standards in multicultural teams	3.46	4.52	1.06
3.1.1.	Refusing compromises that undermine fire protection requirements regardless of pressure	3.68	4.64	0.96
3.3.1.	Diligent and responsible approach to fire protection aspects from early to final stage	3.58	4.53	0.95
3.2.2.	Ensuring fire protection design quality without cutting corners	3.66	4.54	0.88

[1] Note: Indicators are ranked by gap size within each dimension. Gap = M Importance minus M Performance.

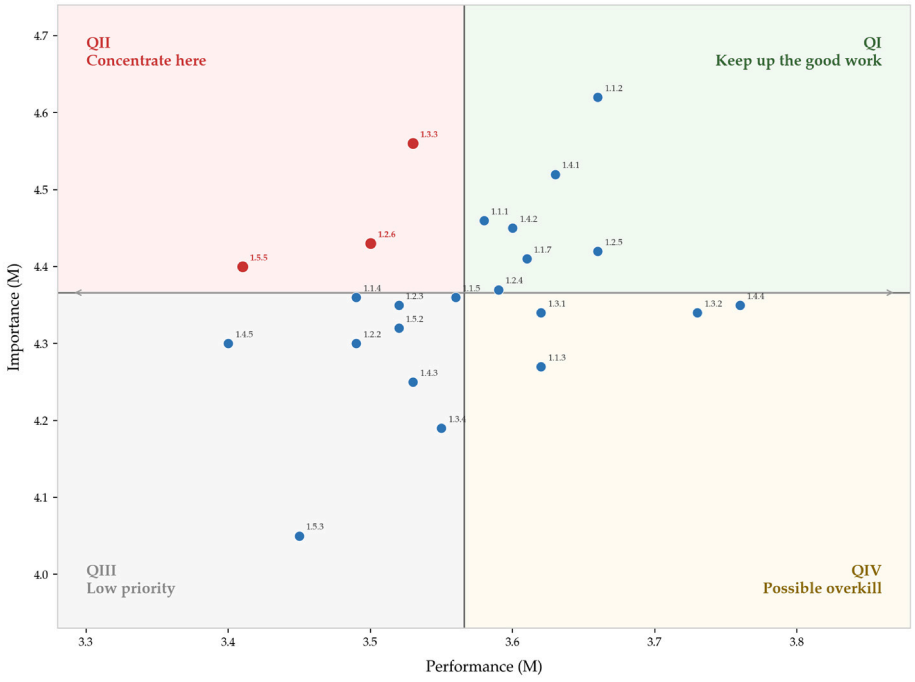


Figure 1. IPA matrix for the Knowledge dimension (N = 250). Blue dots represent standard competency indicators; red dots represent priority competency gaps positioned in Quadrant II (high importance, low performance). Boundary values: M Performance = 3.57; M Importance = 4.37.

A particularly noteworthy finding concerns the attitudes dimension, which—despite recording the highest mean performance among all dimensions (M = 3.70)—simultaneously contained the greatest number of Quadrant II indicators: seven out of 20 attitude competencies, or 35% of the entire dimension. This pattern may be interpreted as an attitudes dimension paradox. Its essence lies in the fact that the professional community assigns exceptionally high importance to ethical, accountability-oriented, and professional attitudinal competencies—to the point where perceived importance exceeds even relatively

high-performance ratings. Consequently, substantial competency gaps emerge even for indicators where assessed performance levels are objectively high.

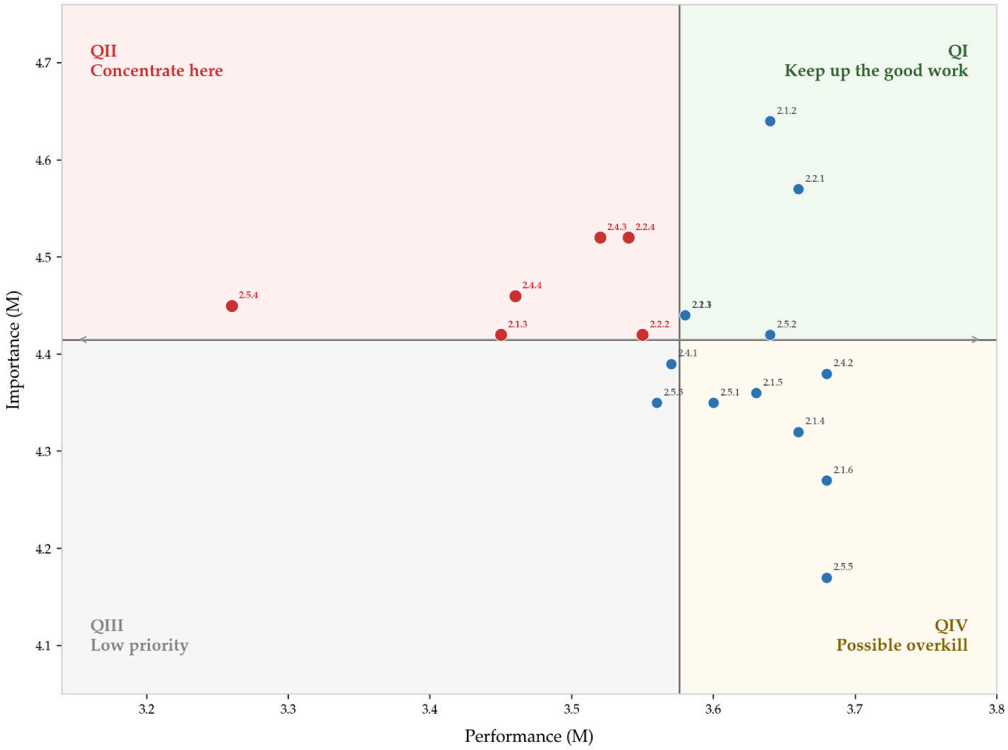


Figure 2. IPA matrix for the Skills dimension (N = 250). Blue dots represent standard competency indicators; red dots represent priority competency gaps positioned in Quadrant II (high importance, low performance). Boundary values: M Performance = 3.58; M Importance = 4.42.

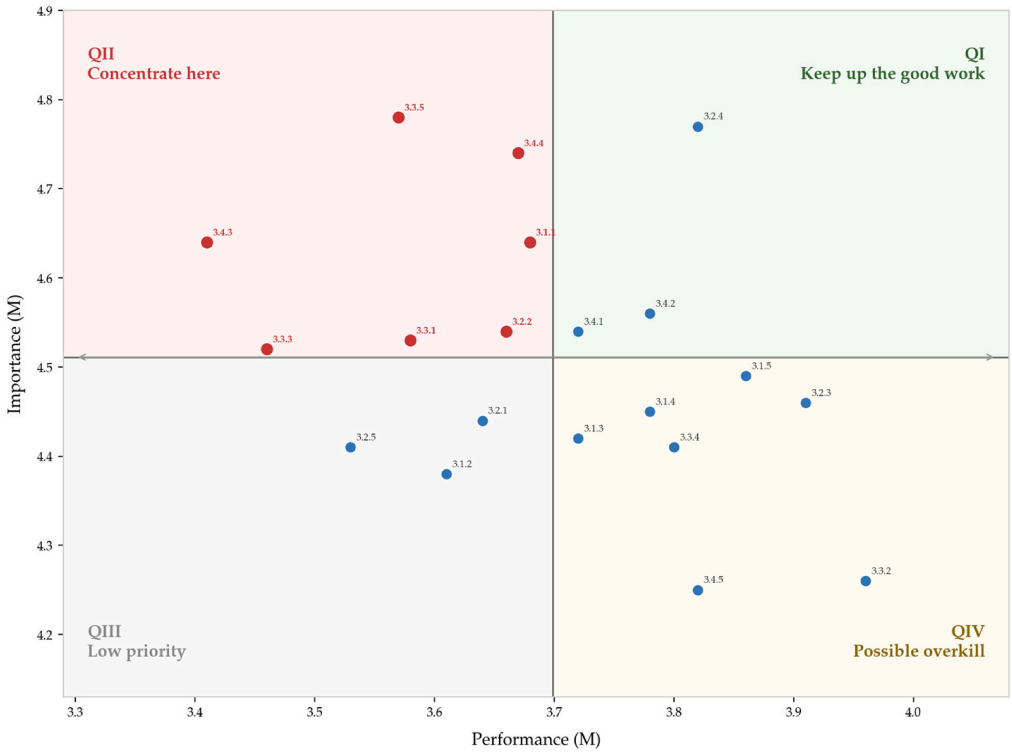


Figure 3. IPA matrix for the Attitudes dimension (N = 250). Blue dots represent standard competency indicators; red dots represent priority competency gaps positioned in Quadrant II (high importance, low performance). Boundary values: M Performance = 3.70; M Importance = 4.51.

3.3. Instrument Reliability and Factor Structure

Internal consistency analysis revealed excellent Cronbach's Alpha coefficients across all dimensions and both scales, confirming the high reliability and psychometric stability of the research instrument. These findings reflect strong inter-item consistency among competency indicators within all KSA dimensions. Cronbach's Alpha values are presented in Table 6.

Table 6. Reliability analysis—Cronbach's Alpha by dimension and scale.

Dimension	Cronbach's Alpha (Performance) [1]	Cronbach's Alpha (Importance) [1]
Knowledge	0.980	0.964
Skills	0.975	0.959
Attitudes	0.978	0.953

[1] Note: All values exceed the threshold of 0.70 recommended for acceptable internal consistency [20] and the threshold of 0.95 indicating excellent reliability.

On the performance scale, Cronbach's Alpha values were 0.980 for the knowledge dimension, 0.975 for the skills dimension, and 0.978 for the attitudes dimension. On the importance scale, corresponding values were 0.964, 0.959, and 0.953, respectively. All values substantially exceed both the widely accepted reliability threshold of 0.70 [20] and the 0.95 threshold indicative of excellent internal consistency. These results confirm that participants understand and interpret competency indicators within each dimension in a consistent manner, further substantiating the psychometric stability of the developed framework. Although Cronbach's Alpha values exceeding 0.95 may theoretically suggest redundancy among indicators, item reduction was deliberately not pursued in the present study for three reasons. First, the competency indicators were constructed and validated through a rigorous three-round Delphi process with 18 domain experts, each of whom independently confirmed the professional relevance and distinctiveness of every retained indicator—providing content validity evidence that supersedes statistical redundancy criteria. Second, high internal consistency in competency frameworks is theoretically expected and methodologically desirable, as indicators within each KSA dimension measure related but distinct facets of a single overarching competency construct. Third, item reduction based solely on Alpha values would risk eliminating UAE-specific indicators—particularly those addressing climatic specificities and Civil Defence coordination—that represent the original empirical contribution of the present study and cannot be replaced by statistically similar but contextually generic items.

EFA was conducted separately for the performance and importance scales to verify the alignment between the empirically derived factor structure and the theoretically postulated three-dimensional KSA model. For the performance scale, the KMO measure of sampling adequacy was 0.986, and Bartlett's test of sphericity yielded a statistically significant result (Chi-Square = 17,240.735; df = 1891; $p = 0.000$), confirming the suitability of the data for factor analysis [21]. Applying Principal Axis Factoring with oblimin rotation, three factors were extracted that together account for 70.06% of the total variance on the performance scale. Factor 1 explained 64.80% of the variance, Factor 2 explained 3.64%, and Factor 3 explained 1.63%, confirming the dominant role of the first factor in the overall factor solution. For the importance scale, the KMO value was 0.972, and Bartlett's test was likewise statistically significant (Chi-Square = 12,210.046; df = 1891; $p = 0.000$). Three factors were extracted explaining a cumulative variance of 54.99%: Factor 1 accounted for 49.20% of the variance, Factor 2 for 3.02%, and Factor 3 for 2.78%. The factor structure obtained for both scales demonstrated a high degree of alignment with the theoretically postulated KSA paradigm, with knowledge, skills, and attitudes indicators clustering into distinct

factors—an outcome that constitutes empirical support for the construct validity of the developed framework.

Pearson correlation analysis of inter-dimensional relationships revealed high and statistically significant correlations among all dimensions on both scales (all $p < 0.001$), indicating strong interconnection among the components of the KSA competency model. On the performance scale, the correlation between the knowledge and skills dimensions was r = 0.896, between knowledge and attitudes r = 0.901, while the strongest association was observed between skills and attitudes (r = 0.915). On the importance scale, correlations were somewhat lower yet remained very high: r = 0.828 between knowledge and skills, r = 0.848 between knowledge and attitudes, and r = 0.852 between skills and attitudes. These findings are consistent with the theoretical premises of the KSA paradigm, whereby knowledge, skills, and attitudes do not represent isolated components but rather interrelated and functionally interdependent facets of professional competence.

3.4. Comparative Analysis

To examine differences in competency perception between architects and FSE consultants, the Mann–Whitney U test was applied separately for each dimension on both scales. Architects consistently recorded statistically significantly higher ranks than FSE consultants across all dimensions on both the performance and importance scales (all $p < 0.05$). This finding is counterintuitive, given that FSE consultants—as highly specialized fire safety professionals—would be expected to perceive competencies as more important and their own performance as higher than architects do. Mann–Whitney U test results are presented in Table 7.

Table 7. Mann–Whitney U test results—differences by professional role.

Dimension	Scale	Mean Rank Architects (n = 139)	Mean Rank FSE (n = 111)	*p*-Value [1]
Knowledge	Performance	138.24	109.55	0.002
Knowledge	Importance	135.88	112.50	0.011
Skills	Performance	136.43	111.82	0.007
Skills	Importance	135.50	112.97	0.014
Attitudes	Performance	137.95	109.91	0.002
Attitudes	Importance	139.04	108.55	0.001

[1] Note: Mann–Whitney U test; all *p*-values < 0.05 indicating statistically significant differences. Higher mean ranks indicate higher perceived performance and importance. FSE = Fire Safety Engineering.

The Kruskal–Wallis test was applied to examine statistically significant differences in competency perception by years of professional experience and level of formal education. The experience analysis comprised four groups: fewer than 5 years, 5–10 years, 11–20 years, and more than 20 years of experience in UAE fire safety practice. The education analysis covered three categories: Bachelor's, Master's, and PhD level.

Results for the experience variable indicate statistically significant differences across all dimensions on both scales (all $p = 0.000$), with a clearly pronounced monotonic increase in mean ranks as years of professional experience increase. Each successive experience category consistently achieves higher ranks than the preceding one, with no deviation from this pattern. The most pronounced effect was observed for the importance of the skills dimension (Chi-Square = 52.996), suggesting that the perceived significance of practical competencies is particularly sensitive to the length of professional experience in fire safety practice. This monotonic increase in competency perception with professional experience is consistent with findings from engineering management competency research, where

years of professional experience have been consistently identified as one of the strongest predictors of competency self-assessment [22].

Results for the education variable likewise indicate statistically significant differences across all dimensions (all $p < 0.01$), with a monotonic increase in mean ranks from bachelor's through master's to PhD level. This pattern demonstrates that higher formal education is accompanied by higher competency perception on both scales, pointing to a systematic association between educational attainment and the evaluation of professional competencies in the fire safety context.

4. Discussion

The results of the present study open several interrelated interpretive directions, examined in detail below: the validity and implications of the Delphi findings, the interpretation of priority competency gaps identified through IPA, an explanation of the counterintuitive Mann–Whitney results, and the theoretical and practical contributions of the developed framework.

The three-round Delphi process yielded a final competency framework of 62 validated indicators with a pronounced and stable level of expert consensus, representing a methodologically sound outcome consistent with recommendations for applying the Delphi technique in competency framework development [12,13]. Of particular significance is the fact that three indicators from the attitudes dimension (3.1.3, 3.1.5, and 3.3.1) achieved full consensus in the first round (SD = 0.000), which is exceptionally rare in heterogeneous expert panels comprising multiple professional groups. These indicators address consistent adherence to UAE FLSC at all project stages, conducting business without bribery or corruption, and maintaining a diligent and responsible approach to fire safety aspects. This pattern points to a high degree of homogeneity of views in the domain of ethical and professional principles, with ethical norms emerging as a stable and unambiguous foundation of professional identity in the UAE fire safety context. While technical and procedural competencies are subject to more differentiated assessments, ethical dimensions appear to enjoy near-universal acceptance among experts. This finding aligns with literature indicating that in high-risk engineering and safety professions, ethical norms and professional accountability tend to function as a "minimum common denominator" of the field, commanding stronger consensus than technical competencies, which are more susceptible to contextual variation and professional specialization [3,23]. These findings are broadly consistent with those reported in Delphi studies applied to fire safety management contexts, where heterogeneous expert panels comprising multiple professional groups similarly require multiple iterative rounds to achieve stable consensus on complex competency-related constructs, and where attitudinal and values-based items consistently demonstrate stronger consensus than technical items across professional boundaries [24].

The fact that 74% of the final indicators were originally constructed or adapted for the UAE context constitutes empirical confirmation of the study's central theoretical premise: that international competency models cannot be mechanically applied to fire safety practice in the UAE without substantial local adaptation. This is particularly evident in comparison with the baseline study by Shyr and colleagues, which demonstrated the applicability of a combined Delphi-IPA approach in the Taiwanese context, yet whose indicators were not directly transferable to the UAE regulatory, climatic, and multicultural environment [16]. This finding is consistent with the conclusions of Lange and colleagues [3], who emphasize that competency frameworks in fire safety are inherently context-dependent, and that global standards must be supplemented with local knowledge and regulatory specificities. UAE-specific indicators, particularly those addressing climatic conditions (sub-dimension 1.3), Civil Defence regulatory procedures (sub-dimension 2.4), and multicultural communi-

cation (indicators 3.3.2 and 3.3.3), represent an original contribution not present in previous fire safety competency frameworks, underscoring the importance of contextualizing competency models to reflect the regulatory, climatic, and professional-cultural conditions of individual jurisdictions.

The identification of 16 priority indicators in Quadrant II of the IPA matrix provides a robust empirical basis for defining targeted educational and professional interventions in UAE fire safety practice. Analysis of their distribution across KSA dimensions, together with a content analysis of individual indicators, reveals three thematic axes structuring the core competency gaps in this professional context. The systematic performance gap observed across all three KSA dimensions in the present study—ranging from 0.80 to 0.84 points—is consistent with findings from IPA-based competency studies in professional education contexts, which consistently report that perceived importance exceeds self-assessed performance across all competency dimensions, with the skills dimension typically recording the largest gap [25]. Fan (2022) similarly documented in an IPA study of professional competencies that attitudinal competencies paradoxically generate the largest number of priority gaps despite recording relatively high-performance levels—a pattern directly mirrored in the attitudes dimension paradox identified in the present study [25].

The first and most pronounced thematic axis concerns digital transformation. Indicator 3.4.3 (adoption of BIM, CFD, and AI in fire analysis) exhibits the largest gap in the entire set (1.23 points), while indicators 2.2.2 (interpreting CFD simulation results) and 2.2.4 (presenting PBD solutions to Civil Defence) further confirm a systemic deficit in digital competencies. This finding is consistent with existing literature documenting the slow and uneven adoption of digital tools within the FSE community. Liu and colleagues identify key organizational and educational barriers to BIM implementation in fire safety [26], while Su and colleagues highlight the considerable potential of artificial intelligence in PBD analysis that remains insufficiently integrated into everyday professional practice [27]. This pattern is particularly pronounced in the UAE construction sector specifically, where studies have identified a lack of BIM awareness, training shortages, and resistance to change as the most critical barriers to digital transformation—confirming that the digital competency gap identified in the present study reflects a broader systemic challenge in UAE professional practice rather than an isolated finding [28]. The urgency of addressing this digital competency gap is further underscored by the UAE's progressive regulatory mandates—Dubai Municipality and Abu Dhabi Department of Urban Planning have progressively introduced BIM requirements for high-rise developments, meaning that professionals who lack digital competencies face direct regulatory non-compliance risks in addition to professional practice deficits [6]. Beyond BIM and AI, the emergence of digital-twin methodologies represents a further frontier of digital competency development in construction practice, enabling real-time simulation and data-driven decision-making across the building lifecycle—a domain in which UAE fire safety professionals will increasingly need to develop competencies as regulatory and client expectations evolve [29].

The second thematic axis encompasses communication and advisory competencies. Indicator 2.5.4 (briefing clients on fire safety implications of architectural decisions) records the second largest gap in the entire set (1.19 points), while indicator 3.3.5 (proactively advocating fire-safe solutions to the client) exhibits a gap of 1.21 points. Together, these indicators point to a systemic deficit in translating technical fire safety requirements into clear, actionable professional recommendations for non-technical stakeholders, particularly clients and investors. This finding is consistent with the broader literature on engineering communication competencies, which consistently identifies client and stakeholder communication as one of the least developed yet most critically important components of professional engineering education and practice [3]. The practical relevance of this gap

is directly illustrated by post-incident investigations of the Address Downtown Dubai fire (2016), which identified inadequate communication between design professionals and facility management teams as a contributing factor to delayed emergency response—underscoring that communication competency deficits carry direct safety consequences in the UAE high-rise context [4].

The third thematic axis concerns regulatory navigation and coordination with UAE Civil Defence. Indicators 2.4.3 (monitoring regulatory changes, gap = 1.00) and 2.4.4 (coordinating final inspection, gap = 1.00) suggest that professionals possess solid baseline procedural knowledge yet fall short in developing the anticipatory and reflective regulatory competence necessary for effective navigation of the UAE's dynamic regulatory framework. This pattern indicates that competencies are predominantly developed reactively, through the execution of already-defined procedures, while the capacity for proactive monitoring, interpretation, and anticipation of regulatory changes remains considerably underdeveloped. In the context of frequent regulatory amendments and a multilayered regulatory structure, this deficit may have direct implications for project coordination efficiency and compliance with regulatory requirements [4,6,30]. This regulatory navigation deficit is particularly consequential given the frequency of UAE FLSC amendments following the Torch Tower fires (2015, 2017) and the Address Downtown Dubai fire (2016), with each revision introducing new compliance requirements that demand proactive professional engagement rather than reactive procedural adaptation [4,6]. Structured decision-support approaches, such as those developed for diagnosing and selecting optimal building repair methods, offer a useful methodological analogy for the development of competency-based professional judgement tools in regulatory navigation contexts [31].

The attitudes dimension paradox warrants interpretive attention. Despite recording the highest mean performance across all dimensions (M = 3.70), this dimension simultaneously contained the greatest number of Quadrant II indicators: seven out of twenty, or 35%. This apparently contradictory pattern may be explained by the exceptionally high normative expectations of the professional community regarding ethical and values-based competencies, which exceed already high-performance levels and generate substantial importance–performance gaps even in areas where competencies are relatively well developed. This finding is consistent with professional identity theory in high-risk engineering professions, according to which ethical norm function as absolute standards of professional conduct rather than relative performance criteria [3]. This finding is further contextualized by research demonstrating that omitted professional actions and inadequate risk awareness in construction practice can directly contribute to safety failures and construction disasters—underscoring that attitudinal competency deficits carry measurable real-world consequences beyond individual professional performance [32].

The finding that architects systematically achieved statistically significantly higher ranks than FSE consultants in the perception of both competency importance and performance across all dimensions (all $p < 0.05$) is counterintuitive and warrants careful interpretation. The intuitive expectation would be that FSE consultants, as a highly specialized profession directly focused on fire safety, would rate competencies in this domain more highly than architects, for whom fire safety represents one among several professional responsibilities. One theoretical lens for interpreting this finding is the Dunning–Kruger effect, whereby highly specialized experts in a narrow domain may be prone to underestimating competencies that extend beyond their primary field of specialization, owing to a greater awareness of the complexity and limits of their own knowledge relative to more generalist profiles [33]. FSE consultants, by virtue of their deep technical expertise in specific fire safety domains, may apply more critical self-assessment in areas bordering on architectural and communication competencies, while architects, with their broader inter-

disciplinary profile, may have developed a heightened awareness of their own competency gaps precisely through a wider professional outlook. An alternative interpretation points to differences in professional socialization between the two groups. Architectural education and practice traditionally emphasize integrative thinking and cross-disciplinary coordination, which may contribute to higher ratings of both the importance and self-assessed performance of the interdisciplinary competencies captured by the KSA framework. In this sense, the finding may reflect differences in epistemological and professional orientations rather than objective differences in actual competence levels. A third theoretical lens draws on professional socialization theory, which holds that the values, self-perceptions, and professional identities of practitioners are shaped not only by technical training but by the broader educational and institutional environments in which they develop their professional identity [23]. Architectural education traditionally emphasizes integrative, holistic thinking across multiple disciplines—structure, esthetics, function, sustainability, and safety—which may cultivate a broader professional self-awareness and a more confident self-assessment across interdisciplinary competency domains [34]. FSE consultants, by contrast, undergo highly specialized technical training that develops deep expertise within a narrower domain, which may paradoxically result in more conservative self-assessments precisely because their training has made them acutely aware of the complexity and depth of fire safety knowledge [33]. This interpretation opens avenues for future research examining the organizational, educational, and contextual determinants of these differences, particularly through qualitative and mixed methods approaches capable of providing deeper insight into the formation of professional self-perception.

At the theoretical level, the present study empirically confirms the context-dependent nature of professional competencies in fire safety. The high proportion of original and adapted indicators (74%) provides measurable evidence of the limitations of generic competency models when applied to the specific regulatory and climatic context of the UAE [35]. The combination of the Delphi technique, IPA, and psychometric testing represents a methodological framework replicable in the development of competency models for other high-risk technical professional contexts beyond the Western European and North American setting, thereby addressing an identified gap in the methodological literature [17]. A comparison with international competency frameworks reveals both convergent and divergent findings. The European framework developed by Lange and colleagues [3] similarly identifies technical knowledge, performance-based design skills, and professional ethics as core competency domains, confirming that these dimensions transcend regulatory contexts. The Australian Warren Centre framework [36], comprising 185 competencies across 26 areas, likewise emphasizes the integration of knowledge and practical skills but does not address multicultural professional contexts or extreme climatic conditions. The North American SFPE Core Competencies framework [37], while providing a globally applicable minimum technical baseline, is primarily technically oriented and does not systematically address the attitudinal and communicative competency dimensions that the present study identifies as priority gaps. These comparisons suggest that while the KSA tripartite structure and the identification of digital transformation as a priority gap are broadly transferable findings, the UAE-specific competency gaps—particularly those relating to Civil Defence coordination, climatic specificities, and multicultural communication—represent context-specific contributions that are not addressable through existing international frameworks.

At the practical level, the developed framework of 62 validated indicators has direct applicability across four institutional levels. For higher education institutions, the identified priority competency gaps, particularly those relating to digital tools, communication competencies, and UAE-specific regulatory content, provide an empirical basis for curricular reform in architecture and engineering management programmes. For CPD programmes,

the distribution of priority indicators across KSA dimensions indicates that interventions should be conceived as multidimensional programmes developing technical, communicative, and attitudinal competencies in parallel, rather than in isolation. Specifically, the identified priority gaps suggest three targeted intervention types: digital competency modules addressing BIM, CFD simulation interpretation, and AI applications in fire analysis (addressing indicators 3.4.3, 2.2.2, and 2.2.4); communication and client advisory workshops developing skills in translating technical fire safety requirements for non-technical stakeholders (addressing indicators 2.5.4 and 3.3.5); and regulatory navigation programmes providing structured exposure to UAE Civil Defence procedures, NOC documentation, and FLSC amendment tracking (addressing indicators 2.4.3 and 2.4.4). At the certification level, the framework provides an empirical basis for the development of UAE-specific fire safety competency endorsements within existing professional licencing systems administered by the Emirates Society of Engineers and the Society of Fire Protection Engineers UAE Chapter. For UAE Civil Defence and other regulatory bodies, the framework validated through a three-round Delphi process with 18 experts constitutes an empirically grounded basis for advancing professional licencing standards and competency evaluation in fire safety practice. Furthermore, the developed framework holds potential for broader application across the GCC region, where comparable regulatory, climatic, and multicultural conditions give rise to similar competency demands [38]. For design organizations, the framework may serve as an instrument for systematically assessing existing employee competencies and developing individualized professional development plans, directly bridging the gap between academic frameworks and organizational practice [3].

5. Conclusions

This study aimed to develop and empirically validate a competency framework defining the knowledge, skills, and attitudes required by architects and FSE consultants for responsible and effective practice in fire safety in the UAE. A three-phase mixed-methods design was employed, encompassing a systematic literature review, a three-round Delphi technique, and IPA, yielding a framework of 62 competency indicators structured according to the KSA model.

Four principal conclusions emerge in response to the research questions guiding this study. Addressing the first research question, a total of 62 competency indicators were identified and confirmed through expert validation, organized across three dimensions and 13 sub-dimensions, with 74% either originally developed or adapted for the UAE context. This empirically demonstrates that international competency models cannot be directly or mechanically applied to fire safety practice in the UAE without substantial local adaptation. Addressing the second research question, IPA identified 16 priority competency gaps in Quadrant II of the matrix, clustering around three thematic areas: digital transformation (the largest identified gap of 1.23 points for indicator 3.4.3), communication and advisory competencies (gap of 1.21 points for indicator 3.3.5), and regulatory navigation and coordination with Civil Defence. Addressing the third research question, the Mann–Whitney U test revealed the counterintuitive finding that architects consistently rated competencies more highly than FSE consultants across all dimensions (all $p < 0.05$), while the Kruskal–Wallis test confirmed a statistically significant increase in competency perception with years of experience (all $p = 0.000$) and level of education (all $p < 0.01$). Addressing the fourth research question, the identified competency gaps carry direct implications for curriculum reform in higher education institutions, the design of CPD programmes, the advancement of professional licencing standards, and the development of organizational competency management systems in the UAE and across the GCC region.

Several limitations should be considered when interpreting these findings. First, reliance on self-reported perceptual measures as the primary data source raises questions about the gap between perceived and actual competence—a limitation inherent to IPA-based methodology that cannot be fully resolved through psychometric validation alone, despite the excellent Cronbach's Alpha values exceeding 0.95 across all dimensions and both scales, and the confirmed three-factor structure obtained through EFA. Second, the cross-sectional design precludes conclusions about competency development over time or causal relationships between experience and competency perception—a limitation that future longitudinal studies would be well-positioned to address. Third, the specificity of the UAE context limits the direct transferability of the findings to other jurisdictions, although the methodology itself is fully replicable and can be applied in comparable studies across the GCC region and beyond.

Several directions warrant attention in future research. Longitudinal studies tracking the development of professional competencies across careers would enable a deeper understanding of their developmental dynamics, a dimension beyond the scope of the present work. Comparative studies within the GCC region, particularly in Qatar and Saudi Arabia, would help distinguish competencies that are shared across the region from those specific to the UAE context. The development of objective competency measurement instruments—such as workplace-based assessment approaches grounded in project portfolios, standardized competency testing protocols, or structured observation methods applied during Civil Defence approval processes—would complement the self-reported perceptual measures used in the present study and provide a more complete picture of actual competency levels in UAE fire safety practice. Such objective instruments would directly address the self-report limitation inherent to IPA-based methodology and enable meaningful comparison between perceived and demonstrated competence. Finally, periodic revision of the competency framework at three-to-five-year intervals is recommended to ensure its continued relevance in the context of rapidly evolving UAE regulatory requirements and the accelerating digital transformation of the construction sector.

The developed framework of 62 empirically validated indicators represents the first instrument of its kind designed for architects and FSE consultants in the GCC region, and provides a solid empirical foundation for advancing education, professional development, and regulatory standards in fire safety in the UAE. Its psychometric robustness, confirmed by Cronbach's Alpha values exceeding 0.95, EFA explaining 70.06% of the variance on the performance scale, and statistically significant comparative findings, ensures that the derived recommendations rest on empirical evidence rather than assumption. In doing so, this study contributes to the broader goal of advancing the safety of building occupants in one of the most dynamic urban contexts in the contemporary world.

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Abbreviations

The following abbreviations are used in this manuscript:

UAE	United Arab Emirates
FSE	Fire Safety Engineering
KSA	Knowledge, Skills and Attitudes
CBE	Competency-Based Education
IPA	Importance–Performance Analysis
CFD	Computational Fluid Dynamics
AI	Artificial Intelligence
PBD	Performance-Based Design
GCC	Gulf Cooperation Council
CPD	Continuing Professional Development
FLSC	Fire and Life Safety Code of Practice
ADIBC	Abu Dhabi International Building Code
NFPA	National Fire Protection Association
ACM	Aluminum Composite Material
EFA	Exploratory Factor Analysis
BIM	Building Information Modelling

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