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Ability to Create Construction Project Cost Estimates: Perception of the Global Academia

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Abstract

The construction industry employs 7% of the global workforce and contributes 13% to the global Gross Domestic Product. In the United States, it significantly affects the lives of a substantial portion of the population. However, the industry grapples with challenges such as declining productivity, workplace safety, and work disputes, necessitating the intervention of construction project managers. To identify training gaps and link qualified construction project managers with relevant projects, it is necessary to understand the competencies required for construction project managers. Through a study, we identified 21 skills necessary for construction project managers and their associated knowledge areas and personality characteristics. To gauge the importance of these competencies, we developed a survey including 672 ranking questions, and proposed an innovative design framework for dividing the lengthy questionnaire to present 21 ranking questions to each participant randomly and evenly. Next, we collected the data from 2,016 academics in relevant fields worldwide. This paper highlights how crucial each knowledge area/personality characteristic is for the ability to create construction project cost estimates. The findings can assist the construction academia in directing their efforts toward key competency development areas, scaffolding courses, and planning curricula to the real needs of the worldwide workforce.

Key Words: Construction Project Management, Knowledge Area, Personality Characteristic, Project Cost Estimate, Skill

Introduction

The construction industry plays a vital role in the global economy, with around 7% of the worldwide workforce engaged in this sector, contributing to roughly 13% of the global Gross Domestic Product (MGI, 2017). In the United States, the construction industry holds significant economic importance and profoundly affects the lives of a substantial portion of the population. In 2019, the construction

sector made a notable contribution of $884 billion to the U.S. GDP (BEA, 2019) and provided employment for over 7.5 million individuals (BLS, 2019).

However, the construction industry in the United States confronts various emerging challenges, including global market competition, disruptive technologies, environmental constraints, an aging workforce, and evolving regulatory demands. These factors, coupled with the industry's vast scope and intricate nature, continue to pose persistent difficulties (Ahn et al., 2012; WEF, 2016).

Advancements in automation, robotics, big data and predictive analysis, industrialized construction, the Internet of Things (IoT), digital transformation, innovative project delivery methods, and additive manufacturing are reshaping many construction jobs and processes (Debra and Anil 2019; MGI 2017; Qureshi 2019). According to the 2013 construction workforce survey by the Associated General Contractors of America, 74% of construction firms encountered challenges in locating a suitable labor force (AGC, 2018).

Debra and Anil (2019) emphasize that the future of the construction sector presents both challenges and opportunities, necessitating collaboration between industry and academia. This collaboration aims to better equip the future workforce to meet the evolving demands of the construction industry. To foster effective cooperation between the construction industry and educational institutions, it is crucial to evaluate how the competencies taught align with the requirements of the future built environment. In particular, it is essential to examine how these competencies can adapt to the transformative changes brought about by industrialized construction (Pariafsai & Behzadan, 2021).

The success of construction projects heavily hinges on the workforce, with a particular focus on the role of construction project managers, as they play a pivotal part in achieving improved project outcomes (Ahn et al., 2012). Given their critical responsibilities, construction project managers should possess a range of competencies that enhance team performance and lead to the desired project outcomes.

This study aims to assess the significance of 10 universal knowledge areas, 10 domain-specific knowledge areas, and 12 personality characteristics concerning the ability to create construction project cost estimates. By determining the importance of these components within construction project management (CPM), the research offers insights into potential strategies for training the next generation of CPM professionals. Furthermore, the findings can assist construction organizations in formulating policies for management development.

Literature Review

Conceptual Model for CPM Competencies

McClelland's concept of competencies, as noted by Vazirani (2010), is likened to an iceberg. The visible tip of the iceberg symbolizes knowledge and skills, while the larger, concealed portion submerged beneath the waterline represents the enduring personal characteristics, as also highlighted by Juneja (2019), Sanghi (2007), and Vazirani (2010).

Furthermore, it is important to recognize that the paths to develop these two levels of competencies differ. Knowledge and skills can be rapidly improved through training and skill-building exercises. In

contrast, enhancing behavioral competencies, as emphasized by Juneja (2019) and Sanghi (2007), poses a greater challenge as they are intricate and demanding to assess and develop.

Literature encompasses various models of competencies. In general, a competency model comprises inherent and acquired elements (Sanghi, 2007). Personal and professional competencies are vital components of human capital quality (Bogoviz et al., 2020). When applied to education and training, competencies are viewed as a cluster of trainable skills, knowledge, and attitudes (van Klink & Boon, 2003).

Competency models designed for effective management typically delineate qualities into three levels: basic knowledge and information, skills and attributes, and meta-qualities. Meta-qualities aid in developing context-specific skills for particular situations (Pedler et al., 2013). Competencies have also been categorized as input and personal competencies. Input competencies encompass the information, comprehension, skills, and capabilities an individual brings to a job, while personal competencies denote essential characteristics that define one's job capacity (Chai, 2016).

Other models group competencies into essential professional skills/talents, personal skills/talents, and behavioral patterns (Blašková et al., 2014). Another conceptual model divides competencies into interrelated knowledge, skills, and personal attributes necessary for job performance, distinguishing knowledge and skills into soft and hard subcategories (Alroomi et al., 2012). Soft skills reflect individuals' identity, while hard skills represent their knowledge. Soft skills and knowledge are challenging to develop, while hard skills and knowledge can be easily cultivated (Alroomi et al., 2012).

An alternative competency model categorizes competencies into behavioral and technical levels. Behavioral competencies encompass abilities and soft skills, while technical competencies encompass knowledge and hard skills (Mohammad et al., 2016). A competency model for crisis management divides competencies into functional and personal levels. Functional competencies focus on task-oriented abilities, while personal competencies relate to managers' readiness to effectively perform tasks (Lovecek et al., 2015).

In the widely recognized International Project Management Association (IPMA) Competence Baseline 3.0, competencies are classified into three categories: technical, behavioral, and contextual competencies (Association, 2006; Omidvar et al., 2011). Technical competencies are crucial for project deliverables, behavioral competencies are essential for managing personal relationships within a project, and contextual competencies are necessary for team interactions within the project's context (Omidvar et al., 2011).

The competency model utilized in this study for CPM is illustrated in Figure 1, classifying competencies into personal and input categories. This model categorizes the competencies essential for CPM into personal and input segments. Personal competencies comprise fundamental personality traits that are challenging to evaluate and enhance. Conversely, input competencies encompass the skills necessary for effective CPM. These skills are further categorized into hard and soft skills. In this model, hard skills are linked to knowledge, while soft skills are associated with core personality traits and knowledge.

Moreover, this conceptual framework groups knowledge into two distinct categories: universal and domain-specific. Universal knowledge areas pertain to those fundamental to all project managers, while domain-specific knowledge areas are specific to project managers in the construction field. In this model, skills are seen as a product of knowledge and personality traits.

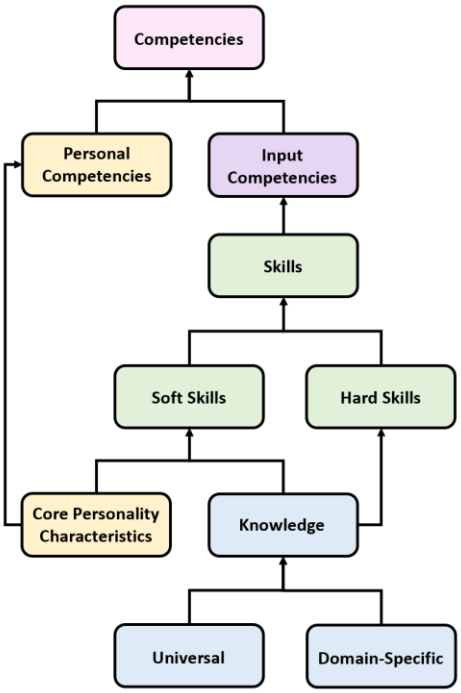

Figure 1. Conceptual competency model for CPM education and training

Identification of Skills, Knowledge Areas, and Personality Characteristics

Various terminology is employed in the literature to describe particular skills. These skills, as outlined in the literature, can be organized into 21 distinct categories depending on their characteristics. This research centers on the specific skill defined as the ability to create construction project cost estimates.

Furthermore, the Project Management Institute (PMI) has formulated a set of ten knowledge areas representing the essential knowledge base for project management (PMI, 2007). In this study, these ten components have been adopted as the universal knowledge areas (UKAs) necessary for CPM. These knowledge areas include project communications management (UKA1), project cost management (UKA2), project integration management (UKA3), project procurement management (UKA4), project quality management (UKA5), project resource management (UKA6), project risk management (UKA7), project schedule management (UKA8), project scope management (UKA9), and project stakeholder management (UKA10) (PMI, 2007).

To compile the list of necessary knowledge areas for CPM, PMI has included the following elements to the existing roster: (a) Project health, safety, security, and environmental management and (b) Project financial management (PMI, 2016). The literature employs various terms to refer to specific knowledge areas essential in CPM. The identified domain-specific knowledge areas (DKAs) were categorized into ten groups based on their similarities: construction operation (DKA1), culture and ethics management (DKA2), legal and contractual management (project claims, conflicts, and dispute management) (DKA3), project change management (DKA4), project environmental management (DKA5), project financial management (DKA6), project health and safety management (DKA7),

project leadership management (DKA8), project security management (DKA9), and project value management (DKA10).

In the literature, various terms are employed to describe specific personality characteristics. To prevent redundancy, the identified personality characteristics from the literature have been categorized into 12 distinct groups based on their inherent nature. These categories include ambition, charisma, creativity, curiosity, determination, leadership, maturity, organization, patience, reasoning, team player, and trustworthiness.

Methodology

Survey Design

A design framework was used to divide the lengthy questionnaire investigating the importance of the knowledge areas and personality characteristics to the skills. The survey includes 672 ranking questions:

- 210 ranking questions regarding the importance of 10 universal knowledge areas to 21 skills
- 210 ranking questions regarding the importance of 10 domain-specific knowledge areas to the 21 skills
- 252 ranking questions regarding the importance of 12 personality characteristics to the 21 skills

The aim was to randomly and evenly present 21 ranking questions to each participant. Each participant should have ranked the importance of two universal knowledge areas, two domain-specific knowledge areas, and three personality characteristics to three skills. Qualtrics, a popular web-based survey tool, was used to design the survey.

Data Collection

The website https://www.topuniversities.com/universities (Symonds, 2019) was used to find top Civil and Structural Engineering departments in different countries worldwide. Next, 35,928 professors, post-docs, and students from 86 countries whose email were available on their department's website were invited to participate. Among the invited people, 2,016 individuals tried the survey.

Analysis

Statistical Test

The one-sample sign test compares values to a given default value for ordinal data. The null hypothesis is that the population median from which the sample was drawn equals the default value. The one-sample sign test was used to investigate whether the five-point Likert scores were significantly different ($p \leq 0.05$) from the default score of 3 representing the response option "important."

Required Sample Size

G * Power has been used to compute the required sample size based on the given α, power, and effect size. For the sign test, G * Power uses the following effect size conventions defined by Cohen in 1969: small g = 0.05, medium g = 0.15, and large g = 0.25 (Buchner et al., 2017). In addition, it is generally accepted that power should be 0.8 or greater (Zint, 2021). For α = 0.05, power = 0.8, and effect size = 0.25, G * Power computed 30 for the sample size of each ranking question. Accordingly, data collection continued until each ranking question was answered by at least 30 participants.

Results

The one-sample sign test results revealed that the participants perceived project cost management, project resource management, project schedule management, and project scope management, but not project procurement management as the universal knowledge area more than important for this skill. They ranked the rest as important (Table 1).

Table 1. One-sample sign test results for UKAs

UKA	p-value	Median - Score			Total
		Negative Differences (Median < Score)	Positive Differences (Median > Score)	Ties (Median = Score)	
UKA1	.523	13	9	18	40
UKA2	.000	22	3	14	39
UKA3	1.000	10	9	19	38
UKA4	.093	16	7	13	36
UKA5	.700	15	12	11	38
UKA6	.043	18	7	15	40
UKA7	.152	16	8	16	40
UKA8	.001	22	4	15	41
UKA9	.001	18	3	17	38
UKA10	.170	9	17	15	41

The one-sample sign test results revealed that, unsurprisingly, the participants perceived project financial management and construction operation as domain-specific knowledge areas more than important for this skill. The one-sample sign test results also indicated that the participants ranked project environmental management as the only domain-specific knowledge area less than important for this skill (Table 2).

Table 2. One-sample sign test results for DKAs

DKA	p-value	Median - Score			Total
		Negative Differences (Median < Score)	Positive Differences (Median > Score)	Ties (Median = Score)	
DKA1	.004	16	3	19	38
DKA2	.189	7	14	16	37
DKA3	.832	12	10	14	36
DKA4	.832	10	12	15	37
DKA5	.017	5	17	17	39

DKA6	.017	17	5	15	37
DKA7	.541	14	10	14	38
DKA8	.541	10	14	14	38
DKA9	.054	8	19	12	39
DKA10	.481	11	7	20	38

The one-sample sign test results revealed that creativity was the only personality characteristic the participants perceived as more than important for this skill. The one-sample sign test results also indicate that the participants perceived ambition, charisma, patience, and curiosity as less than important for this skill. Based on the one-sample sign test results, the participants perceived the rest of the personality characteristics as important for the skill (Table 3).

Table 3. One-sample sign test results for Personality Characteristics

Personality Characteristic	p-value	Median - Score			Total
		Negative Differences (Median < Score)	Positive Differences (Median > Score)	Ties (Median = Score)	
Ambition	.000	7	31	9	47
Creativity	.000	42	0	4	46
Determination	.186	10	18	19	47
Organization	1.000	14	14	19	47
Charisma	.000	5	32	10	47
Team player	.855	14	16	17	47
Leadership	.584	13	17	17	47
Reasoning	.164	21	12	14	47
Patience	.000	4	28	15	47
Maturity	.022	9	23	15	47
Curiosity	.000	4	33	10	47
Trustworthiness	.710	13	16	18	47

Conclusion

The findings of this study revealed that the academia perceived project cost management, project resource management, project schedule management, and project scope management, but not project procurement management as the universal knowledge areas more than important to the ability to create construction project cost estimates. The results also indicated that the academia perceived project financial management and construction operation as the domain-specific knowledge areas more than important for the skill and project environmental management as the only domain-specific knowledge area less than important for this skill. In addition, creativity was the only personality characteristic the academia perceived as more than important for the skill. The academia also perceived ambition, charisma, patience, and curiosity and curiosity as less than important for the skill. The already employed and the newly hired construction project managers must acquire critical competencies on time. Accordingly, a strategic plan is essential to keep construction project managers' competencies up to date and enable them to manage the ever-increasing complexity of the construction industry. The primary steps to reexamine how construction project managers should be educated and trained is to determine the most critical competencies to fill the existing gaps. This study

is a step forward in identifying the most critical knowledge areas and personality characteristics required for the ability to create construction project cost estimates.

The findings of this study contribute to improving CPM training programs and assessment criteria. The results can also assist in refining recruitment criteria and sustainable employability in CPM. Overall, the findings of this study make recommendations for forging the path ahead by assisting the construction industry in directing its efforts on core competency development areas and catering training and professional development to the real needs of the future workforce.

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