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AIC

Accelerating Constructor Excellence

# The Professional Constructor

## Journal of the American Institute of Constructors

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Journal of the American Institute of Constructors

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Founded in 1971, the American Institute of Constructors mission is to promote individual professionalism and excellence throughout the related fields of construction. AIC supports the individual Constructor throughout their careers by helping to develop the skills, knowledge, professionalism and ethics that further the standing of the construction industry. AIC Members participate in developing, and commit to, the highest standards of practice in managing the projects and relationships that contribute to the successful competition of the construction process. In addition to membership, the AIC certifies individuals through the Constructor Certification Commission. The Associate Constructor (AC) and Certified Professional Constructor (CPC) are internationally recognized certifications in the construction industry. These two certifications give formal recognition of the education and experience that defines a Professional Constructor. For more information about the AIC please visit their website at **www.aic-builds.org**.

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- A qualifying body to serve the individual in construction, the Constructor, who has achieved a recognized level of professional competence;
- Opportunities for the individual constructor to participate in the process of developing quality standards of practice and to exchange ideas;
- Leadership in establishing and maintaining high ethical standards;
- Support for construction education and research;
- Encouragement of equitable and professional relationships between the professional constructor and other entities in the construction process; and
- An environment to enhance the overall standing of the construction profession.

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# The Professional Constructor

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# Current State of the Workforce Demographics and Knowledge Transfer Strategies in the Southeast United States

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## ABSTRACT

The construction industry is a very diverse industry due to the unique nature of projects and expertise within various construction companies driven by multiple regional/national factors. The United States Department of Labor reported 44% of the current US employed population will be above 65 in eleven years by 2028, making workforce studies and knowledge transfer a key driver in leading construction business models. This study conducted an in-depth investigation in the southeast region of the US on the current state of workforce demographics and the need for knowledge transfer within the ranks of management coupled with trade personnel. The study sample included general contractors, specialty contractors/trade partners from the commercial and residential sector. This study was conducted in two phases. Phase 1 focused on establishing the urgency of the research area on workforce demographics and knowledge transfer through an industry-wide survey. Phase 2 conducted a literature review, data collection, and quantitative analysis to document the current state of workforce demographics and knowledge transfer (WD-KT) with validation from subject matter experts (SMEs). The study findings indicated 46% of the workforce in the southeast region will be retiring in the next 20 years. The study also correlated workforce demographics to knowledge transfer to evaluate the utilization of knowledge management strategies.

**Key Words**: Workforce, Knowledge Management, Retirement

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## INTRODUCTION

Various studies have identified challenges that pertain to workforce demographics and resulting knowledge loss. Essential, competitive, critical knowledge is walking out the door daily, so addressing the issue is a priority. With baby boomers reaching retirement age, highly experienced employees are leaving en masse. Organizations are realizing the need to address business-critical, experience-based knowledge loss (Leonardo et al., 2015). As baby boomers migrate toward retirement and continue to leave the workforce, they are taking with them decades of intellectual capital in strategies, products, services, relationships, and how-to -invaluable organizational memory (Ippoliti, 2016).

Knowledge and knowledge management are recognized as valuable corporate resources in the same vein as land, buildings, financial resources, people, capital equipment, and other tangible assets (Kipley et. al., 2008; Stevens, 2016). To remain competitive, companies need to develop strategies to retain this knowledge from older workers and transfer it successfully to other corporation employees (Calo, 2008; Mihelic, 2015). As the baby boomer generation prepares for retirement, many firms want to be sure that the knowledge and experience gained by the current leadership do not walk out the door when they do (Glick, 2007; Stevens, 2016). A growing concern among organizations is the vast wealth of knowledge and experience built by baby boomers walking out the door (Paton, 2008). Experienced executives contain crucial know-how; if this information were to be lost, it would result in a pricey undertaking for the organization to recover that information, if even at all (Martin, 2000). According to the National Center for Construction Education & Research, approximately 41 percent of the current construction workforce, most of which are in management roles, will retire by the year 2031 (NCCER, 2019).

The retirement rate is directly correlated with knowledge drain without proper knowledge management strategies in place. The current study focuses on measuring the retirement rates via workforce demographics study and correlates it with the implementation of knowledge management strategies in the southeast region of the US. The main objectives of this study are 1) to measure the retirement rate of the current workforce, 2) the level of implementation of various knowledge management strategies, and 3) to understand the perception of industry outlook on workforce and knowledge transfer strategies.

The study is organized into six sub-sections. Each section analyses the data in the following categories: Age Distribution, Gender Distribution, Workforce shortage, COVID-19 Impact on workforce shortage and recruitment, Knowledge Management Perception, and Knowledge transfer strategies currently employed.

## LITERATURE REVIEW

The construction market in the United States is one of the largest in the world, with private spending reaching 977 billion U.S. dollars in 2019 and with about 11.2 million people employed in the industry. In the meantime, the value-added of the construction industry contributed 4.1 percent of the gross domestic product in the United States. It is expected that new construction put in place will total 1,449 billion U.S. dollars by 2023 (Raynor, 2021). Recent Bureau of Labor Statistics (BLS) data indicate that the 2016–2026 compound annual rate of change for employment in the construction sector is projected to be 1.2%, which follows closely the top leading industries (i.e., 1.9% for healthcare, 1.4% for mining, and 1.3% for educational services) (BLS 2017). When older people retire or leave, the construction industry loses proficient skills and knowledge, and the rate of younger people entering the industry is much lower than the rate of retirement. Another concern highlighted by the Department of Labor is a

demand for replacement of the aging workforce that is retiring or otherwise leaving the industry (Kim, et al. 2020).

**Workforce Demographics**

The workforce is clustered into the following major generational categories: the Veterans, born before 1945; the baby boomers, born between 1946 and 1964; Generation X, born between 1965 and 1979; Generation Y born between 1980 and 1996; and Generation Z, born between 1997 and 2012 As of 2019, the baby boom generation comprises approximately 70 million people or 21% of the total U.S. population. Generation X, the generation that follows the baby boomers, only makes up 65 million people or 20% of the total U.S. population (STATISTA, 2019). The incoming talent is inadequate to replace the aging and retiring baby boomer generation. In 2017, the generational composition of the workforce consisted of approximately 2% Veterans, 25% baby boomers, 33% Generation X, and 35% Millennials (BLS, 2017).

**Knowledge Loss**

Knowledge is a key asset for any organization (Murray and Durcikova, 2013). Knowledge loss risk impacts the organization caused by the loss of a human knowledge source, usually an expert, a knowledge worker, or a manager. Knowledge loss from losing an employee has three impacts (Massingham, 2001) :

1. Loss of contribution to the organizational memory
2. Loss of relational knowledge with the internal and external social network (fellow employees and customers)
3. Loss of work performance resulting in decreased organizational productivity (there is a decrease in the organization's ability to perform the tasks it completed before the employee left)

In other words, a lost employee results in lost know-how, know-who, know-what (Eucker, 2007; Sumbal et al., 2018). General Mills Inc., for example, has estimated that the departure of just one experienced marketing manager could cost millions of dollars from the loss of critical marketing and client knowledge (Lancaster and Stillman, 2002).

**Workforce Demographics Impact on Knowledge Retention / Transfer**

Davenport and Prusak (1998) defined knowledge as "a fluid mix of framed experience, values, contextual information, and expert insights that provides a framework for evaluating and incorporating new experiences and information. It originates in and is applied in the minds of knowers". The dominant classification of knowledge in organizations divides it into two types, tacit and explicit. The critical differences between these two types are found in three major areas—modifiability and mechanisms for transfer, methods for acquisition and accumulation, and the potential to be collected and distributed (Lam, 2000). Tacit knowledge can be thought of as the know-how acquired through personal experience (Nonaka, 1994). On the other hand, explicit knowledge can be easily codified, stored at a single location, and transferred across time and space independent of individuals (Lam, 2000). This combination of explicit and tacit knowledge that mature workers possess has become the most strategically significant resource of organizations' (Calo, 2008).

A study (Sumbal et al., 2017) conducted in the oil and gas industry suggests that companies need to undertake knowledge retention to capture knowledge possessed by the retiring workers. Knowledge

retention is a relatively new field that deals with capturing the knowledge of departing employees. Levy (2011) stated that knowledge retention, a sub-discipline of knowledge management, has not been fully covered in academic research. Martins and Meyer (2012) defined knowledge retention as "maintaining, not losing, the knowledge that exists in the minds of people (tacit, not easily documented) and knowing (experiential action manifesting in behavior) that is vital to the organization's overall functioning". Durst et al. (2015) defined knowledge leakage in terms of knowledge loss and knowledge retention.

Shifting workforce demographics has a notable effect on organizations across various industries and geographies (Lesser, 2006; Sumbal et al., 2017). Hence, many organizations are looking to solve many important knowledge and learning-related challenges. Industries, as diverse as electric utilities, oil and gas producers, healthcare, and the public sector, are feeling the effects of employee retirements and the difficulty in sourcing new talent. In some companies, increasing numbers of employees are retiring, leaving with sizable amounts of knowledge that can place the organization at risk. For others, the challenges include maintaining a productive workforce in the face of potentially shrinking labor pools and the increased mobility of the younger generation of employees. According to a joint study by the American Society of Training and Development (ASTD) and International Business Machines (IBM), the majority of organizational learning executives report that the maturing workforce coupled with the smaller labor pools will impact their organization (Lesser and Rivera, 2006).

The construction industry and academia have identified various knowledge transfer strategies and their definitions currently implemented by the firms (Caldas et al., 2015; CII 2014). The definition for various knowledge management strategies is outlined in Table 1.

It is evident from the previous studies that an understanding of workforce challenges and demands at a national level is essential for a robust future workforce. However, workforce demands are also governed by the regional construction market. Most of the studies regarding workforce and knowledge transfer do not precisely apply to the specific region within the construction industry. The current study focuses on the perception of the workforce challenges in the southeast region and correlates it with the need to implement knowledge management strategies.

**Table 1.** Knowledge Transfer Strategies:

| No | Strategy | Definition |
|---|---|---|
| 1 | Job Shadowing | The pairing of an experienced individual with incoming talent to observe, internalize, and eventually collaborate with the expert.<br><br>This method provides means to pass on tacit knowledge through socialization and collaboration with the expert. |
| 2 | Attend meetings as an Observer | Provides an opportunity for an incoming talent to absorb the experiences from a cumulative knowledge base of experts through meetings. |
| 3 | Lessons Learned | Documentation/database of knowledge gained from successes and challenges to guide similar future actions. |
| 4 | Mentoring/Coaching | "Mentoring requires an experienced individual to help their mentee's professional development by being available and approachable for sharing their wisdom and insight and for helping to develop the decision-making capacity of their mentees" |
| 5 | Web-based Collaboration/ Communication | Use of online forums, discussions, networks, and other infrastructure to connect incoming talent with subject matter experts, generally not locally available. |
| 6 | Lunchtime Seminar | Includes a brief presentation, or series of presentations, to a group based on experiential knowledge pertinent to the common area of focus. |
| 7 | Job Rotation | An approach to gain broad experience across various organizational operations. |
| 8 | Grooming assignment | Generally used for succession planning into leadership roles within organizations. It is a strategy for upcoming talent to network, understand the responsibilities and knowledge necessary to succeed in their future role. |
| 9 | Peer Group Networks | Provides an informal setting to exchange information among peers or supervisors. |
| 10 | Outsourcing/<br><br>Acquisition | The hiring of external expertise when the task is either cost or time prohibitive. |
| 11 | Keep Retired Connected | Engage retired employees in various activities such as<br><br>training, consulting, seminars, and meetings as needed. |
| 12 | Simulations | Working around hypothetical scenarios in problem-solving sessions. |
| 13 | Narrative Database/ Storytelling | Experienced individuals share a narrative of their experience with incoming talent in a formal or informal setting. |
| 14 | Standardized College Program/Course | Company or subject matter-specific training modules in a classroom setting. |
| 15 | Community of Practice | A facilitated meeting with a group of like-minded |

## METHODOLOGY

The study was conducted in two phases as shown in Figure 1.

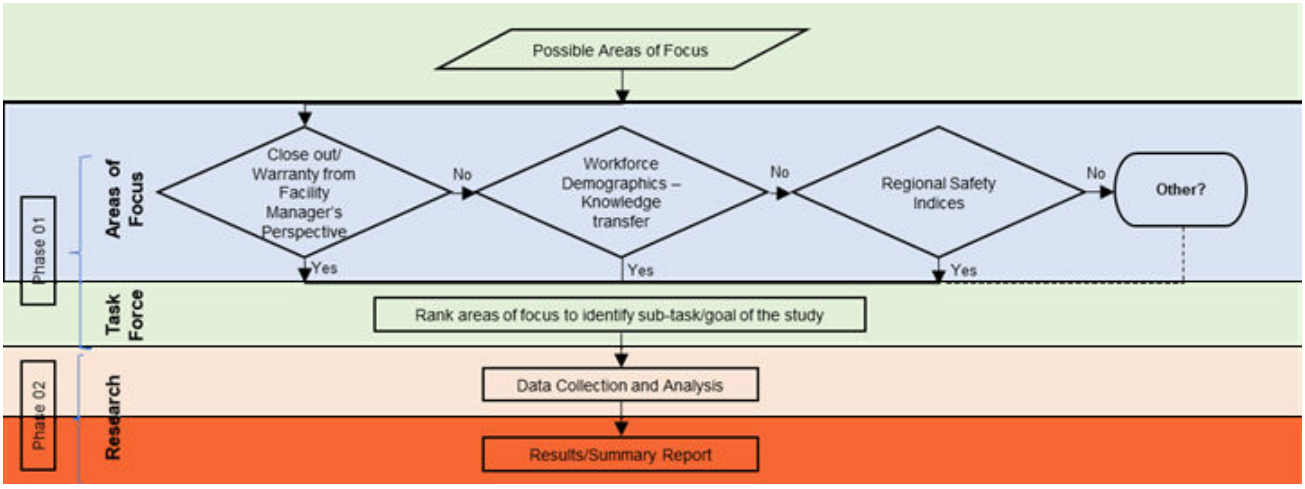



**Figure 1**. Flowchart of the Study Approach

- Phase 1: Forming the steering committee with SMEs and identifying the key area of focus for the study. A preliminary survey was conducted with the companies in the southeast region to identify an area of focus among four distinct challenges in the industry.
- Phase 2: This phase included conducting a literature review, survey development, data collection, data analysis on the current state of the workforce demographics, and the urgency for knowledge transfer in the southeast region.

A survey was distributed to a total of sixty-six (66) organizations from the construction industry in the southeast region. To build synergy between the construction industry and academic researchers for innovative solutions and better business outcomes, a steering committee was formed which comprised of nine (9) companies from the commercial and residential sector. The regional footprint of the companies in the southeast region of the US is shown in Figure 2.


**Figure 2.** Companies Geographical Presence

**Survey Development**

A preliminary survey with the southeast regional companies investigated various areas of focus. The participating companies voted for *Workforce Demographics and Knowledge Transfer* in the southeast region among other key areas such as Close-out / Warranty and Safety Performance. The SMEs within the steering committee and the research team collaborated to develop a focused survey on workforce and knowledge transfer for the southeast region. The key elements of the survey as listed below.

1. Background Information (Company location, Company type, Industry sector, Company presence, Annual sales)

2. Workforce Demographics (Total employees within the regional division, Age distribution of the workforce for field and management personnel, Generational distribution of the workforce, Gender distribution, Perception of the workforce shortage for the past five years, within one year, and the future )

3. COVID-19 impact on the workforce structure

4. Knowledge Management / Knowledge Transfer (Current use of knowledge transfer strategies, Perception of knowledge management culture)

**Pilot Testing**

The final survey was created based on the literature review of previous studies and inputs from the steering committee. The survey instrument was validated by the SMEs within the steering committee. SMEs and the researchers also collaborated throughout the study for continuous feedback and validity on the overall study approach.

**Data Collection**

The survey was distributed electronically and made available to HR managers and owners of the participating companies for eight months. Data collection was extended to a period of eight months due to the COVID-19 pandemic. A total of sixteen (16) companies responded to the survey representing a total of 5,208 employees.

**Data Analysis**

The analysis for the southeast region, including general contractors and sub-contractors from the commercial and residential sector was conducted as follows:

1. Age Distribution
    a. Analysis of workforce age distribution by region, contractor type, and sectors.
    b. Distribution of professionals based on their position
2. Gender Distribution
    a. Analysis of male/female / other by region, contractor type, and sectors
3. Workforce Shortage Perception

a. Analysis on the perception of workforce shortage for the last five years, within one year and the next five years for management and skilled labor positions by region, contractor type, and sectors

4. COVID-19 Impact

a. Analysis on the perception of workforce shortage due to COVID-19 pandemic for management and skilled labor positions by region, contractor type, and sectors

5. Knowledge Management Strategy

a. Analysis of the use/awareness of various knowledge management practices by region, contractor type, and sectors.

6. Knowledge Management Perception

a. Analysis on the perception of organization's knowledge management strategies and culture.

b. Analysis of the perception of the accessibility of knowledge management tools and the availability of a dedicated knowledge manager.

## ANALYSIS / FINDINGS

The survey was distributed to sixty-six (66) companies in the southeast region. A total of sixteen (16) companies representing 5,205 employees responded to the survey with a response rate of 24%.

**Age Distribution**

**Table 2.** Age Categories

| Age Categories | # | % |
|---|---|---|
| Traditionalist (75 & above) | 60 | 1 |
| Baby Boomer (57-74) | 804 | 15 |
| Gen X (43-56) | 1,507 | 29 |
| Gen Y (24-42) | 2,294 | 44 |
| Gen Z (23 & below) | 540 | 10 |
| Total | **5,205** | **100** |

The survey instrument identified the age categories of all the employees of the respondent companies. A total of 5,205 employees were categorized based on their generations as shown in Table 2. The respondent companies were not able to provide age categories for 248 employees.

The data were analyzed to evaluate the retiring age of the employees of the respondent companies. The retirement age was assumed to be sixty-five (65) years for this study. For the purpose of the analysis, as shown in Figure 1, the researchers assumed that half of the baby boomer workforce is above sixty-five (65) years of age. The retirement age was analyzed in ten-year increments.

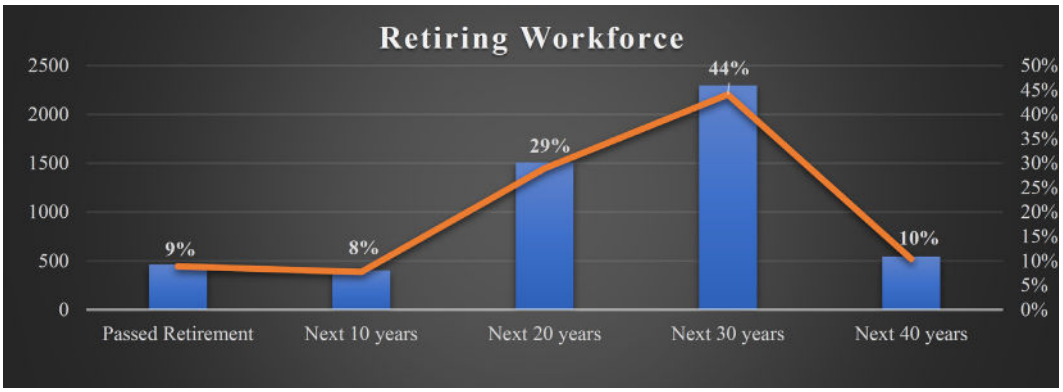
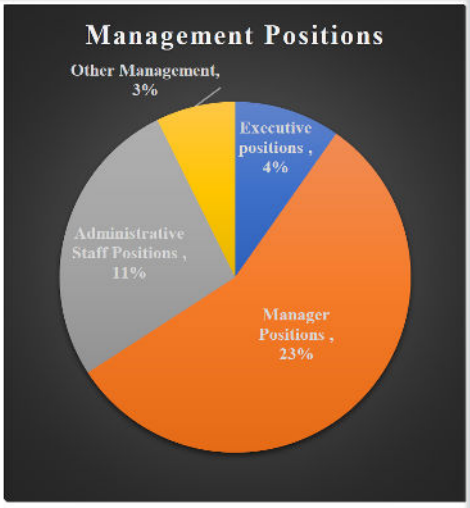



**Figure 4.** Retiring Workforce in the Southeast Region

A total of thirty-seven percent (37%) of the surveyed workforce in the southeast region is expected to retire in the next twenty (20) years by 2041.

| Management Positions | # | % |
|---|---|---|
| Executive | 201 | 4% |
| Managers | 1,236 | 23% |
| Administrative Staff | 595 | 11% |
| Other Management Personnel | 176 | 3% |
| **Total** | **2,208** | **42%** |




| Field Positions | # | % |
|---|---|---|
| Sr. Superintendent | 618 | 11% |
| Assistant Superintendent | 227 | 4% |
| Field Project Engineer | 167 | 3% |
| Foreman | 381 | 7% |
| Journeyman / Skilled Labor | 1,661 | 31% |
| Other Field/Skilled Personnel | 191 | 3% |
| **Total** | **3,245** | **58%** |

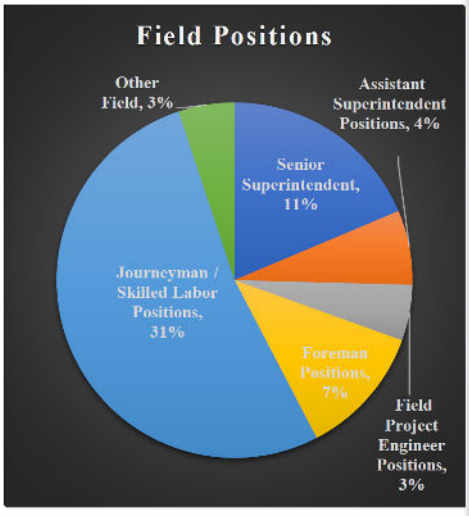



**Figure 5.** Management and Field Positions Distribution

A total of nine percent (9%) of the surveyed workforce is already above the retirement age. However, this analysis needs to be supplemented with the current supply and demand of the industry. The survey also identified the number of professionals in management positions and field/skilled labor positions as shown in Figure 5.

The management positions consist of:

1. Executive Position: Owner, President, VP's, Directors, operations Manager, etc.
2. Manager Position: Project Manager, Assistant Project Manager, Estimator, Project Engineer, etc.
3. Administrative Staff Position: Accountant, HR, etc.
4. Other Management Personnel: Safety Manager, QA/QA Manager, etc.

The field/skilled labor position consists of:

5. Senior Superintendent,
6. Assistant Superintendent
7. Field Project Engineer
8. Foreman
9. Journeyman/ Skilled Labor
10. Other Field/Skilled Personnel

The survey was distributed to general contractors and sub-contractors. The positions from (8) to (10) for general contractors are represented by their self-performing crew.

**Gender Distribution**

The survey instrument identified the gender distribution of all the employees of the respondent companies. A total of 5,208 employees from the southeast region representing different contractor types and sectors were categorized by gender, specifically male, female, and other genders. The respondent companies were not able to provide gender categories for 245 employees. A ratio of 4,469 males compared to 739 females was observed in the southeast region of survey respondents as shown in Figure 6.

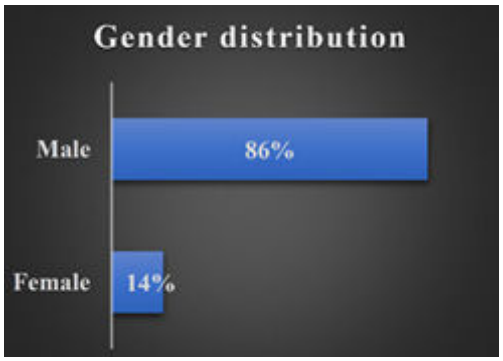



**Figure 6.** Gender Distribution

### Workforce Shortage Perception

As a first step, this study identified that a total of thirty-seven percent (37%) of the surveyed workforce in the southeast region is expected to retire in the next twenty (20) years by 2041 whereas a total of nine percent (9%) of the surveyed workforce is already above the retirement age. This analysis was reinforced by understanding the supply and demand of the industry. The supply and demand of the industry were captured through a perception survey on the workforce shortage by management and field/skilled labor positions. The perception of the workforce shortage from the sixteen (16) respondent companies was analyzed for the past five years, within one year and the future as shown in Figure 7.

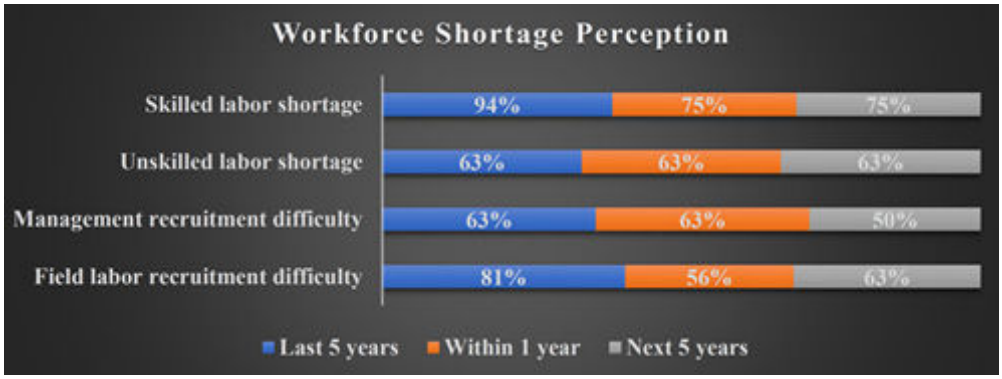



**Figure 7.** Workforce Shortage Perception

It is evident that there were severe workforce shortages for both management and filed/skilled positions in the past. For example, ninety-four percent (94%) of the respondent companies faced a shortage of skilled labor in the last five years. The current and the future outlook seems better than the past five years but still indicates acute workforce shortages. The perception for difficulty in recruiting management positions seems to improve from sixty-three (63%) for the past five years to fifty percent (50%) over the next five years. However, the steering committee attributed this finding to the nature of the construction industry in being optimistic about the future. The gravity of the workforce challenge needs to be viewed with both the retirement workforce and the current and future workforce shortages.

This finding is further validated by other studies by Kim, et al. (2020) and Fenner, et al. (2018) which portends that the industry continues to face workforce shortages. Kim, et al. (2020) has identified an aging workforce as one of the four critical causes of workforce shortage in the construction industry.

### COVID- 19 Impact

As an unprecedented COVID-19 pandemic engulfed the world, a natural curiosity to understand the impact of COVID-19 on the perception of workforce shortages was included in this study. In addition, the survey instrument identified the perception of the difficulty in recruiting the workforce for labor positions and management positions. The respondents were provided with the option to choose high vs. low impact due to COVID-19 for the four perception questions as shown in Figure 8. It was observed that every other company predicted the skilled labor workforce shortages due to the COVID-19 pandemic compared to management positions. The difficulty in recruitment was observed as forty-four percent (44%) for labor positions and thirty-eight percent (38%) for the management positions.

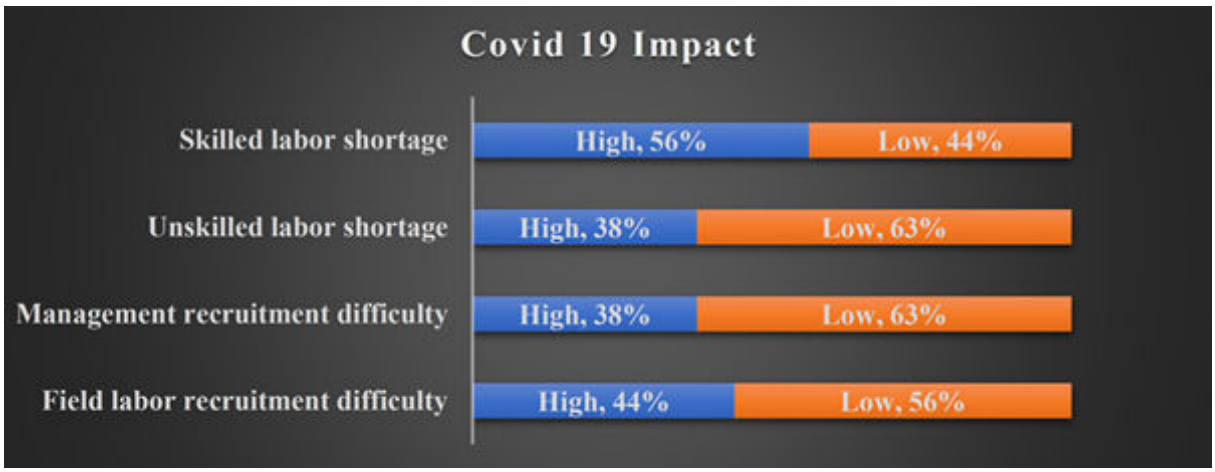



**Figure 8.** COVID-19 Impact

**Knowledge Transfer Strategies**

A total of thirty-seven percent (37%) of the surveyed workforce in the southeast region is expected to retire in the next twenty (20) years by 2041. A total of nine percent (9%) of the surveyed workforce is already above the retirement age. It is also evident, from the perception of the respondent companies, that there are severe workforce shortages for both management and filed/skilled positions. Multiple studies across various sectors have identified the need to undertake knowledge retention/transfer strategies to capture knowledge possessed by the retiring workers. With increasing numbers of baby boomers retiring, the institutional and tacit knowledge needs to be retained and transferred to the replacement professional which translates into higher investment for organizations in training.

The survey instrument identified the current knowledge transfer strategies employed by the respondent companies as shown in Figure 7. It was observed that the top three (3) knowledge transfer strategies currently utilized by the respondent companies are:

1. Job shadowing
2. Attending meetings as an observer
3. Lessons learned.

The three (3) very effective knowledge transfer strategies least utilized by the respondent companies are:

1. Community of practice
2. Standardized college programs
3. Narrative databases

Further investigation is warranted in identifying and developing best practices implementation strategies for successful knowledge management programs.

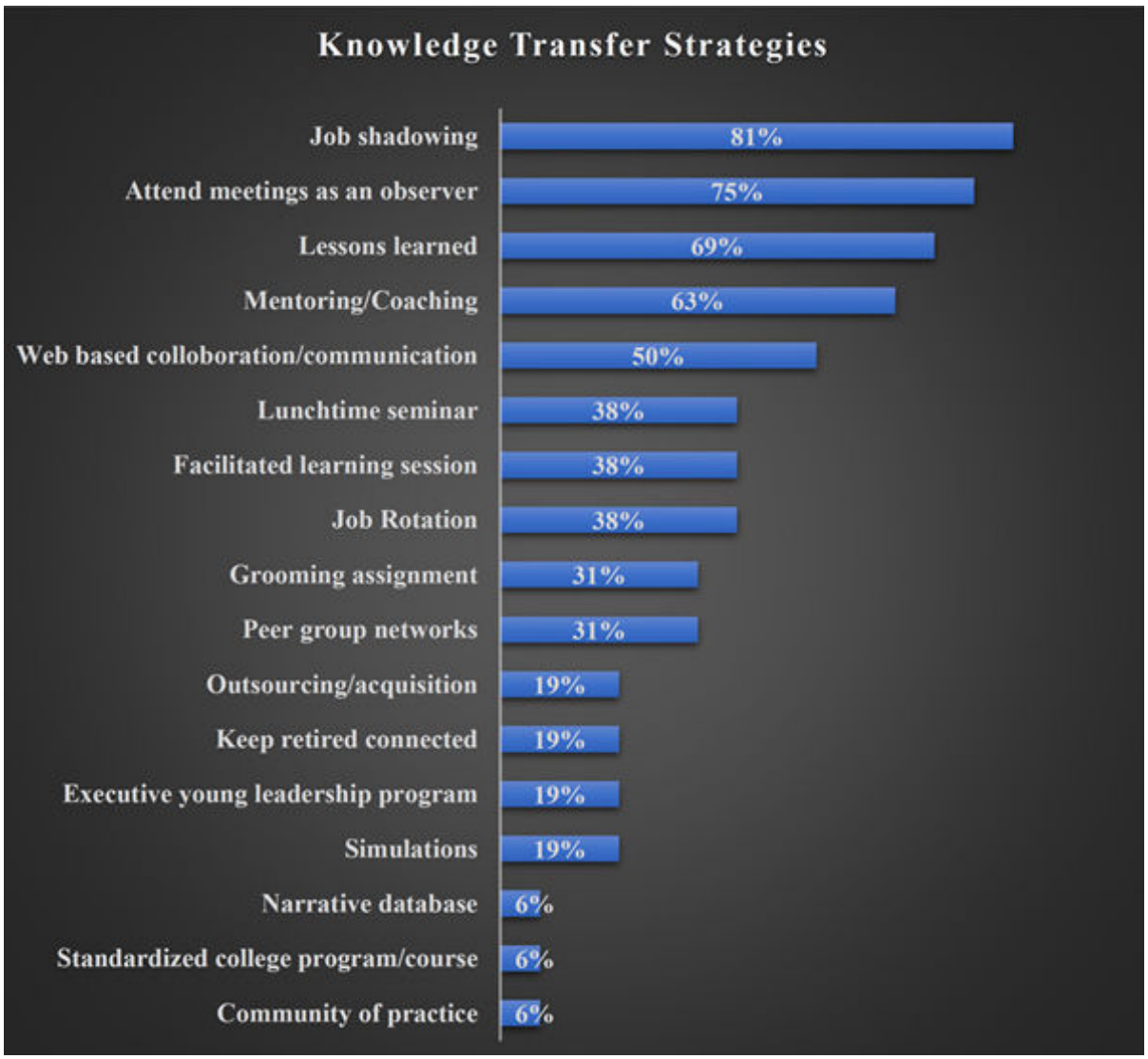



**Figure 9.** Utilization of Knowledge Transfer Strategies in the Southeast Region

### Knowledge Management Program Perception

Along with knowledge management strategies, the perception of the respondent companies regarding knowledge management culture was evaluated. Knowledge management culture perception was measured in two sections.

The first section identified the respondent companies' perception of proactive knowledge management culture, awareness regarding knowledge management strategies, support within organizational leadership, and culture as shown in Figure 9.

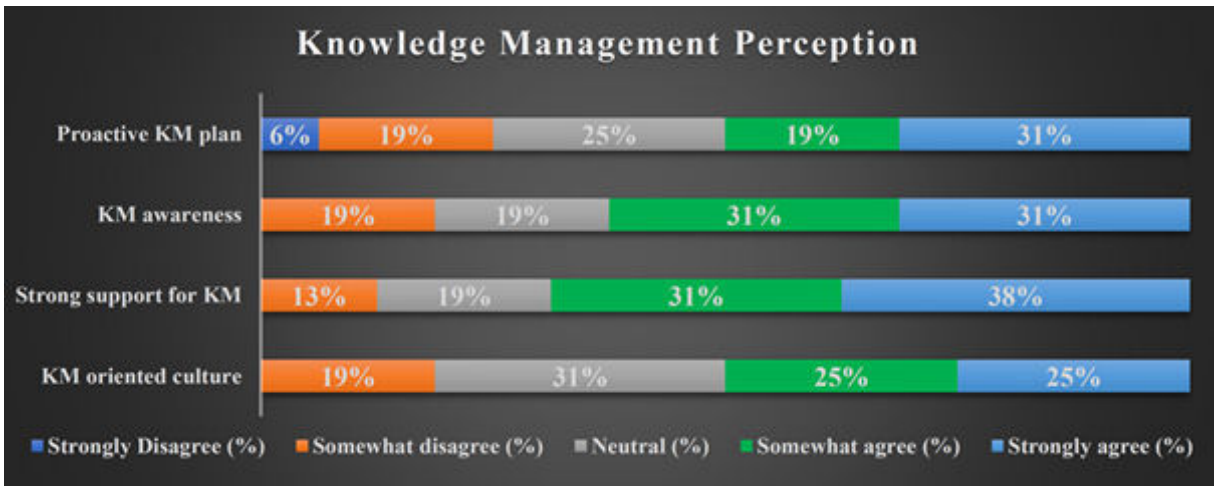



**Figure 10.** Knowledge Management Perception

For analysis, knowledge management perception was compared between the respondent companies that strongly agreed to the rest. For example, sixty-three percent (63%) of the participating member companies didn't believe there was strong support for knowledge management among leadership, whereas seventy-five percent (75%) of the respondent companies did not strongly believe that they have knowledge management culture in their organizations. It is noteworthy that sixty-nine percent (69%) of the respondent companies do not think they have a proactive knowledge management plan or awareness.

Still, fifty-five percent (55%) of respondent companies believed that there are measures in place for knowledge management within their organization. As a follow-up, the respondent companies were asked dichotomous questions on the accessibility of knowledge management tools and databases within their organization, a formal knowledge management program, and/or if there is a dedicated knowledge management professional within their organization, as shown in Figure 10.

It was observed that only 25% of the respondent companies had a dedicated knowledge manager, with only 32% of the participating companies with a formal knowledge management program. It is a significant observation that reinforces the finding from the perception survey that indicated only an average of 31% strongly supported knowledge management culture.


**Figure 11.** Knowledge Management Program Validation

## CONCLUSION

As initially indicated, the retirement rate is directly correlated with knowledge drain without proper knowledge management strategies in place. The current study successfully measured the retirement rates of the current workforce demographics study and identified the implementation level of knowledge management strategies in the southeast region of the US. As the last objective, the study provided the industry's level of perception on workforce and knowledge transfer strategies.

A total of thirty-seven percent (37%) of the surveyed workforce in the southeast region is expected to retire in the next twenty (20) years by 2041. This concern cuts across various sectors, contractor types, and the region included in the study. Out of 5,205 employees from the respondent companies, a total of nine percent (9%) of the surveyed workforce is already above the retirement age. To put this in perspective, about half of the workforce is either retiring in the next twenty (20) years or has already passed retirement age for both management and field positions. This challenge is further compounded by the fact that there is a chronic shortage of talent in the industry within both management and field positions.

Gender distribution was expected to bear skewed findings, and it was validated with only fourteen percent (14%) of females among the workforce across all sectors. There is a further need to understand the types of positions and attraction/retention factors for the female workforce within the industry (in the southeast region).

An unprecedented pandemic due to COVID-19 compelled the researchers and the steering committee to measure COVID-19's impact on the workforce. After the initial economic slowdown in the industry, the flow of work was sustained; however, every other respondent company predicted workforce shortages due to the COVID-19 pandemic. Initial perception survey showed 94% of the surveyed companies faced skilled labor shortages, and 81% of the companies had difficulty recruiting skilled labor positions – COVID-19 will most likely worsen the workforce dynamic. A continuation of this study could include the impact analysis of COVID-19 on the retiring workforce/baby boomers. However, the impact of COVID-19 is not grave on management professionals since only 38% of companies reported a high impact of COVID on the management positions shortage and the difficulty in recruiting the management positions.

The retiring baby boomers compound the challenge of workforce shortage along with the loss of knowledge. Every retiring worker equates to the loss of knowledge, and replacing this knowledge is considered critical for the survival and success of the organization. Hence, the researchers and the steering committee engaged in an extensive literature review on knowledge management strategies. It was observed that the top three (3) knowledge transfer strategies currently utilized by the respondent companies are:

i. Job shadowing

ii. Attending meetings as an observer

iii. Lessons learned

Out of the seventeen (17) knowledge management strategies, more than half (12) had less than 50% utilization by the respondent companies. The knowledge management strategies that have the highest potential for implementation are:

i. Mentoring/Coaching

ii. Lunchtime seminars

iii. Facilitated learning sessions

iv. Job rotation

The Knowledge Management Perception survey findings indicate a long road ahead for a structured knowledge management emphasis within the industry similar to other accepted areas such as quality assurance or safety. Sixty-two percent (62%) of the participating member companies didn't believe there was strong support for knowledge management among leadership. In contrast, seventy-five percent (75%) of the respondent companies did not strongly believe that they have a knowledge management culture in their organizations. It was observed that only 25% of the respondent companies had a dedicated knowledge manager, with only 32% of the participating companies with a formal knowledge management program. It is a significant observation that reinforces the perception survey findings that indicated only an average of 31% strongly supported knowledge management culture

The study identified serious concerns with respect to field and management workforce demographics and knowledge management for respondent companies in the southeast region. However, future research is essential to evaluate workforce demographics and knowledge transfer for contractor type (general contractors and specialty contractors) and sectors (commercial, residential, industrial).

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# Educating the Construction Client: Training Strategy for Buyers of Commercial Design and Construction Services

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## ABSTRACT

*Business owners can face a myriad of challenges when venturing into a new construction project. Most of the design and construction process is unfamiliar territory as compared to their customary business operations and owners face a wide assortment of issues when making the decision to build a new facility. Consequently, the majority of owners are entirely out of their business element when deciding to enter into the undertaking of a new building project. Since most of the risk with any given project rests with the Owner, better training and strategies for owners will lead to a higher likelihood of project success while achieving pre-determined goals and objectives. Using interviews and survey questionnaires this research explored and developed a core group of construction owner's greatest obstacles which in turn was used to develop an owner's training strategy to address architect selection, contractor selection, project financing, and pre-project checklist as well as detection of potential problems during the course of the project.*

**Keywords:** owner training, stakeholders, areas of concern, risk

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## INTRODUCTION

When an owner decides to seek professional services for the design and construction of a facility, they are confronted with a broad variety of choices. The type of services selected depends to a large degree on the type of construction and the experience of the owner in dealing with various professionals in the previous projects undertaken by the firm. Generally, several common types of professional services may be engaged either separately or in some combination by the owners (Hendrickson 2000). Construction service buyers (CSB), also referred to as "the client or project owner" are the life-blood of the building industry. It is widely known that most projects have a broad range of associated stakeholders (See Table 1) whose interests and concerns can influence the project's shape and progress to a greater or lesser extent (Ward & Chapman 2008 ). The project owner is the primary stakeholder and thus the entity with the most influence and power to affect key decisions. This category includes both the homeowner who builds only one house in a lifetime and the multinational company that has numerous facilities built (Gould 2012). Their investment of time, money, and resources as well as the need for new facilities fuels the continuing operations of the construction industry; i.e. they are the '*demand'* side of supply and demand macroeconomics in the building industry. Without their vision, determination, and willingness to take risks, the building industry as we know it would barely exist. Stakeholders play an important role in any construction project not only as interested observers but active participants. While cooperative relationships among project stakeholders, such as owners, contractors and consultants, play an important role in project performance, the construction industry experiences greater levels of conflict than other industries owing to the adverse interests of the project parties (Lu & Hao 2012). On the owner's side there can be many stakeholders; i.e. those with some level of vested interest in the outcome of the project (see Table1). It is imperative at the outset of any project that the key stakeholders agree on how to define success and develop the assessment metrics (criteria) to be aligned with the expectations. Perceptions of success by stakeholders are significant, as are perceptions of important criteria and actual performance (Davis 2013).

**Table 1. Defining Stakeholders**

| # | **Description** |
|---|---|
| 1 | Any group or individual who can affect or is affected by achievement of a project's purpose |
| 2 | Individuals or organizations that are actively involved in the project or whose interests may be affected as the result of project execution or completion |
| 3 | Those who have an input in the decision-making procedure on a project |
| 4 | Those to benefit from the outcomes of any decisions regarding a project |
| 5 | Those that contribute voluntarily or involuntarily to the project's financial success |
| 6 | A person or group of people who have a 'vested interest' in the success of a project and the environment within which the project operates |
| 7 | People or groups that have, or believe they have, legitimate claims against the substantive aspects of a project |
| 8 | Groups or individuals who have a stake in, or expectation of, a projects' performance |
| 9 | Those who experience or anticipate experiencing potential benefits as a result of the organizations actions |

As Table 1 illustrates the Owner can have many stakeholders involved in the project and early on in the projects' conception it's in the Owner's best interest to limit the stakeholder group who will be in a decision-making capacity to "direct interest" entities; defined as various parties who may affect the form, progress, and outcomes of the project (Ward & Chapman 2008). The benefits will be realized when dealing with the other members of the project team; design team and contractor. Stakeholders can be divided into internal and external; internal stakeholders being those directly

involved in an organization's decision-making process (Atkin 2008). The definition of an Owner can take on many forms (see Table 2) and the importance of a common understanding of the role, duties, and responsibilities of a construction owner are key to the investigatory aspect of this paper.

**Table 2. Definition of an Owner**

| # | **Description** | |
|---|---|---|
| 1 | Owners can be individuals seeking a home for their growing family, a large organization responding to change in technology, a municipality seeking to improve its infrastructure or a developer working to make money filling a perceived market need | (Gould, 2012) |
| 2 | The owner may be an individual, a group of individuals, a corporate entity, an institution, or a government agency | (Coleman, 2004) |
| 3 | The owner, also called the client, is the person or organization that will pay the bills as well as receive the ultimate benefits of the finished project | (Gould, 2012) |
| 4 | The owner is the party that determines when a particular project is needed | (Hinze, 2010) |
| 5 | The owner, whether they are public or private, is the party that provides financing and hires the design team and contractor | Author |

Whether the owner is a public entity using tax dollars to build schools or improve infrastructure or a private investor using their own funds they both are susceptible to many variables, both internal and external, that may affect the successful completion of any given project. Project owners can be divided into three distinct groups as identified by their experience in the building process. Type 1 owners are experienced in the construction process and have been involved in many building projects of varying degrees of scope, complexity, and cost. These are usually large companies who often have a separate department of professionals who represent them during the design and construction process (Gould 2013). Type 2 owners have built multiple buildings but still are not fluent in the factors intrinsic to the construction process. Type 3 owners have never been involved in a building project before. For purposes of this research project, the focus was on creating a sense of "*construction awareness*" for the inexperienced CSB previously identified as Type 2 or 3.

## LITERATURE REVIEW

An extensive literature search was conducted to determine to what extent, if any, training that is available to inexperienced or relatively inexperienced procurers of design and construction services. *Little has been written or researched that focuses solely on the construction project owner and the challenges that face them*. Most of the published literature focused on how architects, engineers, and contractors go about managing a construction project with little information developed specifically for the actions of the owner. The results of the literature review did however reveal a common thread of issues that construction project owners have faced or experienced within their sphere of influence or that was of concern to them in terms of affecting the overall success of construction projects; (1) setting specific project goals and objectives, (2) identifying and selecting the most appropriate project delivery method, (3) selection of the design team, (4) selection of the contractor, (5) developing the most effective financial model, (6) identify a suitable decision-making process, (7) how to deal with changes, and (8) recognizing problem projects. Most certainly there are other issues facing construction owners but historically the aforementioned eight areas have occurred with regular frequency on the vast majority of construction projects. Construction is a process governed by complicated contracts and involving complex relationships in several tiers (Abdou 1996). For most projects the tiers are the owner, architect, and contractor which is not to imply the contractor or architect is on a tier higher than the other. The majority of owners do not understand all of the basic concepts of most of the options available to them (Galloway 2006).

Very little information was revealed in the area of owner training of in-house staff as it pertains to being prepared to manage construction projects from the owner's side. Many owners have the option of performing some or all of the functions of their business process with in-house staff or by utilizing external service providers (Levy 1994); i.e. professionals from the architecture, engineering, and construction industry (AEC). This outsourcing of sorts to professionals from the AEC sector provides a means for the construction owner to take advantage of their various skill sets and expertise and also provides a mechanism to reduce the inherent risk associated with any given construction project.the

## OBJECTIVE, RESEARCH QUESTIONS, AND HYPOTHESES

The objective of this project was to investigate the obstacles (issues) owners encounter when venturing into a new construction project and from that an approach, develop a "*training strategy*" which owners can use to better prepare themselves for future projects. To that end three research questions were developed as the underlying driver to investigation of the topic and achieving the objective; (1) what are the most commons obstacles owners encounter when starting a new project? (2) what can owners do to better prepare themselves for an upcoming project? And (3) What are the major areas of concern (issues) you have encountered as a construction project owner that you felt you were ill-prepared to address and felt additional training would have helped in the management of those issues?

For this research the hypotheses are as follows:

$H_o$: There is not a common set of obstacles accepted by the AEC industry in which most project owners encounter throughout the course of the building construction activities

$H_a$: There is a common set of obstacles accepted by the AEC industry in which most project owners encounter throughout the course of the building construction activities

## PROBLEM STATEMENT

Many construction owners, as purchasers of design and construction services, will eventually have to make a series of choices as to which architect and contractor to hire. Due to the complexity of the design and construction process and the fact that for many owners the new construction project is an unknown domain, the choices they must make can be an uninformed one or at the very least choices made without enough information to make an assessment as the best decision for their project. More pre-project training needs to be made available to construction owners to better prepare them for what can be a complex and unpredictable process. In addition, more in-house training should be provided to owners' personnel who will be involved in the management of upcoming construction projects.

## METHODOLOGY

The methodology used as the underpinning of this research was conducted in multiple phases to support the overall research objective: (1) conduct an extensive and comprehensive literature review to determine the level of research or investigation that has been accomplished in the area of owner training for construction projects; (2) using the findings of the literature review develop survey instruments to send out specific target owner groups (types) to identify the major areas

of concern; (3) send out surveys to project owners; (4) collect and analyze the data to determine any commonalities in the response ranges; (5) conduct telephone interviews with respondents to confirm data and collect any additional information. The majority of the training strategy content was developed as a result of the post-survey interviews.

A group of ***Type 1*** owners were identified from large metropolitan areas that the researcher was familiar with and had worked within. The group represented health care, elder care, higher education, industrial, and public/municipal. Initial phone calls were made to confirm participation in the research. Surveys were sent to this group to develop a baseline of information that accurately reflected the current state of the industry in terms of what owners should be concerned with while planning a new construction project (see survey questionnaire in the Appendices). A group of ***Type 2*** owners were identified from a group the author had worked with in the past and/or have been referenced from individuals within that group. This group represented institutions of health care, elder care, higher education, and public/municipal. Surveys were sent to this group to develop a second baseline of information that accurately reflected the current state of the industry in terms of what owners should be concerned with while planning a new construction project (see survey questionnaire in the Appendices). A group of ***Type 3*** owners, who at the time of the research were seriously contemplating a new construction project, were contacted via phone interviews to determine what their initial concerns were relative to the design and construction process (see phone interview questionnaire in the Appendices). The data was assembled, sorted, and organized in accordance with the research objectives to identify similarities and differences within the responses. Respondents were also allowed to provide elaborated comments outside the structure of the survey questions

## DATA COLLECTION

The data was collected from emailed surveys and phone interview notes with the following response rates for each owner type: Type I = 71%; Type II = 72% and Type III = 67%. The overall purpose of the multi-pronged approach was to confirm the most critical issues facing CSB's and to identify any correlational responses between the three respondent groups. The resulting primary outcomes of the data collection were twofold: (1) confirmed and developed the most common areas of concern and (2) created the basis for the owner training aspect of this paper, i.e. specific measures to assist owners in addressing issues inherent to the construction process. The confidence level for the questions asked the respondents (via survey) was not determined to be necessary since according to (Minchin et al 2010) "a confidence level calculation is not valid for a voluntary survey because underlying factors could exist as to why some respondents chose to respond and others did not".

## RESULTS

The data collected in the surveys and interviews confirmed the information discovered in the literature review and revealed several common threads of evidence in the form of four distinct and predominant areas of concern: (1) selection of the most appropriate architect that can ensure the owner's vision is realized, (2) selecting the best contractor to build the job; (3) recognizing problem construction projects; and (4) project financing. For purposes of this research project the aforementioned four areas of concern were incorporated into the owner training strategy. Type 1 and 2 owners were asked to respond to the following statements or questions:

- Question #1 asked the respondents to indicate their alignment with the statement: As the owner we feel we are adequately prepared prior to venturing into our construction projects
- Question #2 asked the respondents to indicate their alignment with the statement: Training for in-house staff is an important investment that would significantly enhance the success of the project

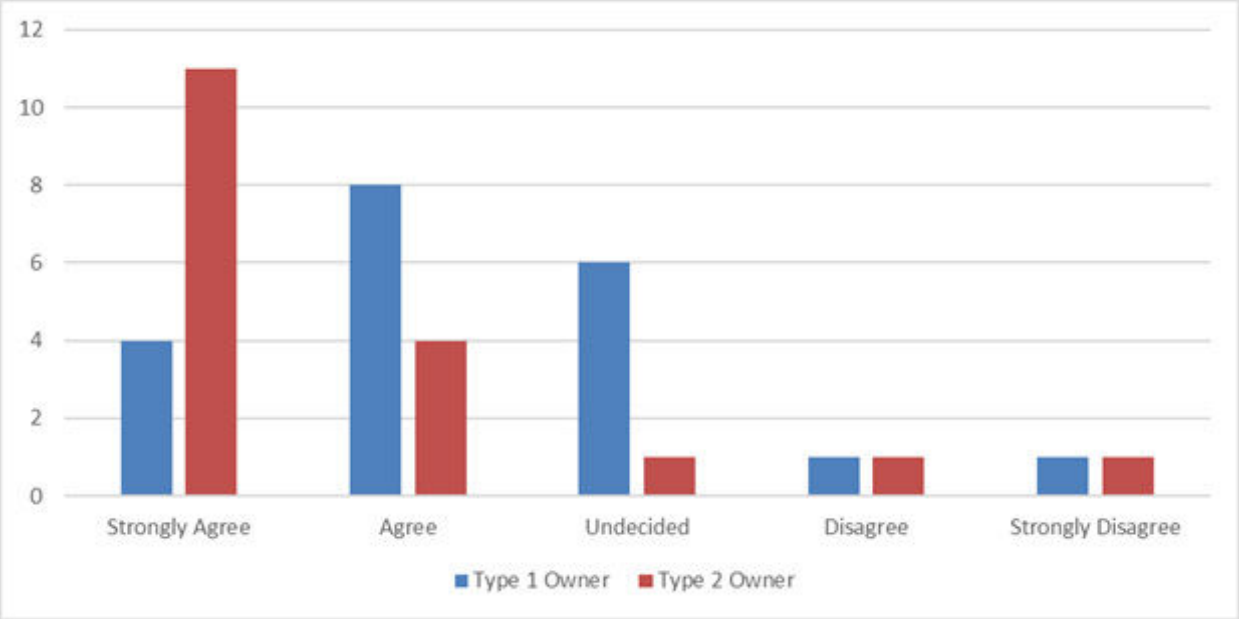


**Figure 1. Question #1 Responses**

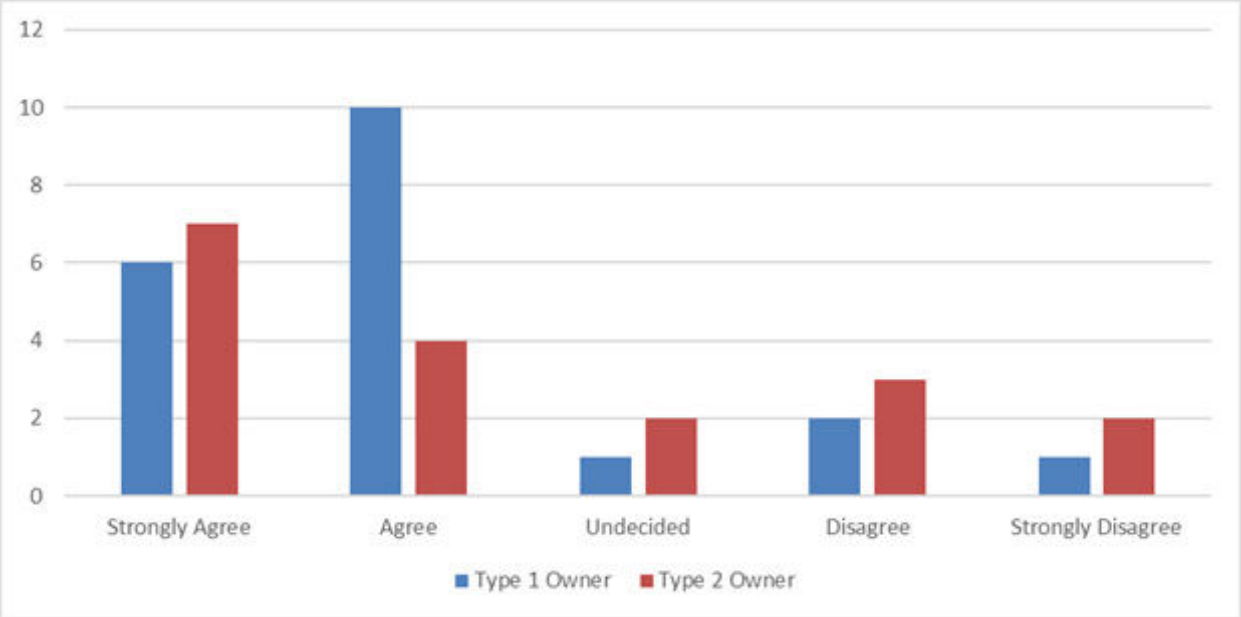


**Figure 2. Question #2 Responses**

The data in Figures 2 and 3 indicates the following perceptions/observations from the two owner groups:

- Type 1 owners did not feel adequately prepared for construction projects but did feel

training for in-house staff was an important investment

- Type 2 owners felt more strongly that they were prepared for construction projects but also felt in-house training would be an important investment

A *t-test* was used to determine if there was any statistical difference between the mean responses of the two groups and helped determine that there was no significant difference between the Type 1 and Type 2 owners regarding how they felt about being prepared for an upcoming construction project.

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{s_1^2}{N_1} + \frac{s_2^2}{N_2}}}$$

For question #1, the *P-value = 0.0345* and for question #2 the *P-value = 0.0102*. In both instances the results indicate the differences to be not statistically significant and therefore supports the alternate hypothesis, $H_a$

Table 4 represents the responses to question #3 on the survey from Type 1 owners:

- What are the major areas of concern (issues) you have encountered as a construction project owner that you felt you were ill-prepared to address and felt additional training would have helped in the management of those issues?

**Table 4. Type 1 Owner Areas of Concern**

| Area of Concern | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | Totals | % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Method of project delivery | ● | ● | | ● | ● | ● | ● | | | ● | ● | ● | ● | | ● | ● | ● | 13 | 76 |
| Change orders/ changes | | ● | ● | ● | ● | ● | | ● | ● | ● | ● | | | ● | ● | ● | | 12 | 71 |
| Architect selection | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | 17 | 100 |
| Location of project | ● | ● | | ● | ● | | | | ● | ● | ● | ● | | | ● | | ● | 7 | 59 |
| Contractor selection | ● | ● | ● | ● | ● | ● | ● | ● | | ● | ● | ● | ● | ● | ● | ● | ● | 16 | 94 |
| Appropriate contract | ● | | | | | ● | ● | | ● | | | ● | ● | | | ● | | 7 | 41 |
| Quality of work | ● | ● | ● | ● | | | ● | | ● | ● | | ● | | ● | ● | | ● | 11 | 65 |
| Decision making | ● | | | | ● | ● | ● | ● | ● | | | ● | ● | | ● | | | 10 | 53 |
| Clear goals and objectives | ● | ● | | ● | ● | ● | | ● | ● | ● | ● | ● | ● | ● | ● | | ● | 14 | 82 |
| Awareness of problems | ● | ● | ● | ● | ● | | ● | ● | ● | ● | ● | ● | ● | | ● | ● | ● | 15 | 88 |
| Safety | ● | ● | ● | | | | ● | ● | | ● | | ● | ● | | | ● | ● | 10 | 59 |
| Schedule | ● | ● | ● | ● | | ● | ● | ● | ● | | ● | ● | ● | ● | | ● | ● | 14 | 82 |
| Appropriate design | ● | ● | | ● | | ● | | ● | ● | ● | | ● | ● | | | ● | ● | 11 | 65 |
| Financing | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | | ● | 16 | 94 |
| Municipal approvals | ● | ● | ● | ● | | | ● | ● | ● | ● | ● | ● | ● | | ● | ● | | 13 | 76 |

*Note to Table: A thru Q represent separate owner respondents*

As Table 4 illustrates owners place a very high value on architect selection, contractor selection, and how to finance the project and a low value on which is the most appropriate contract to use and the decision-making process. For most construction projects the priorities would likely to change as the project progresses from concept to construction. Table 5 represents the responses to question #4 on the survey from Type 2 owners;

- What are the major areas of concern (issues) you have encountered as a construction project owner that you felt you were ill-prepared to address and felt additional training would have helped in the management of those issues?

**Table 5. Type 2 Owner Areas of Concern**

| Area of Concern | A | B | C | D | E | F | G | H | I | J | K | L | M | Total | % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Method of project delivery | ● | | | ● | ● | ● | | ● | ● | | | ● | ● | 8 | 62 |
| Change orders/changes | ● | ● | | ● | | ● | ● | ● | | ● | | ● | ● | 9 | 69 |
| Design team selection | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | 13 | 100 |
| Contractor selection | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | 13 | 100 |
| Appropriate contract | | | ● | ● | | ● | ● | ● | ● | | ● | | ● | 8 | 62 |
| Decision making | ● | ● | | ● | | ● | ● | | ● | ● | | | ● | 8 | 62 |
| Clear goals and objectives | ● | ● | | ● | ● | | ● | ● | ● | | ● | ● | ● | 10 | 77 |
| Awareness of potential problems | ● | ● | ● | ● | | ● | ● | ● | ● | ● | ● | ● | ● | 12 | 92 |
| Safety | ● | ● | | ● | | ● | | | | ● | | ● | | 6 | 46 |
| Schedule | ● | ● | | ● | ● | ● | | ● | ● | ● | ● | ● | | 10 | 77 |
| Financing | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | 13 | 100 |
| Municipal approvals | | | ● | ● | ● | | | | | ● | ● | ● | ● | 7 | 54 |

*Note to Table: A thru M represents separate respondents*

As Table 5 illustrates, similar to the Type 1 owners, high value is place on architect and contractor selection as well as the project financing model and low value on safety and municipal approvals. Phone interviews were conducted with the Type 3 owners instead of surveys due to their inexperience in the design and construction process and general unfamiliarity with terminology used within the AEC industry.

In addition, the follow comments were generated from the phone interview sessions and determined to be relevant information as to their approach to a given project:

- As an owner we do not presently have an in-house process to help us decide which architect or contractor to select
- Most owners relied on industry reputation or contacting references to determine if they are hiring the right architect or contractor
- Most owners felt (85%) hiring the contractor presented them with more risk than hiring the architect
- All of the owners clearly stated it would be beneficial to them and the AEC industry to have a process or strategy developed to assist them in architect and contractor selection as well as other types of training to better prepare them for construction projects.

## DISCUSSION AND ANALYSIS

The data collected strongly supports the alternate hypothesis ($H_a$) that there are a common set of obstacles or hurdles owners must overcome when venturing into a new construction project. The problems reveal themselves in different ways to each of the three owner types. Not all obstacles are presented in each project but the common threads are identified as:

- Uncertainty as to how to select the architect or evaluation metrics that should be used in the selection
- Uncertainty as to the best method to select the most suitable contractor
- Development of the most suitable project financing model
- How to avoid a project laden with problems

Since Type 1 and Type 2 owners are similar in that they both have some level of experience in the design and construction process and both groups were asked the same questions, comparative analysis was performed across the range of responses to see if there were any significant differences between the two owner groups. The results of the responses to questions 1 and 2 on the survey indicate there was no significant difference between the responses, and therefore no inherent issues with the survey instrument and generally reliable data was collected. Additionally, there were many similarities between the responses of all three owner groups.

## TRAINING STRATEGY

The training strategy models were developed directly as a result of the identification of the four most common areas of concern as identified by the three types of construction project owners; (1) architect selection; (2) contractor selection; (3) recognizing problem projects; and (4) project financing. In addition, comments from follow-up interviews were used to augment the survey data to formulate a more comprehensive strategy that owners can apply for upcoming construction projects. The following training strategy was designed to focus on, and will prove most useful to, the inexperienced Type 3 owner but can certainly be utilized by Type 1 and 2 owners.

## DESIGN TEAM SELECTION

Design team selection was identified by 100% of the respondents for Type 1 and 2 owners and was also identified as a major area of concern in the interviews with Type 3 owners with specific emphasis placed on the uncertainty of choosing an architect who can transform their vision into a built project. As shown in Figure 1, once the owner identifies a need for a project the next step is to select a design team (A/E) that will be able to meet the owner's overall design-related project objectives. Owners have many criteria to consider when selecting the A/E. Each of them will have a different level of importance in the context of the final selection. Selection of the best design team will allow the owner to realize many tangible benefits all along the project time line to include a design that not only transforms their vision into a realistic design but also a design that will meet cost, form, function, and schedule objectives.

Table 6 outlines a "*sample*" selection process which assigns a different level of importance (or weighting) to a range of selection criteria. Selection criteria were developed from two sources; (1) the researchers experience as an owner's project representative and (2) comments from the

follow-up interview sessions. Each firm under consideration is then rated on a scale of 1 to 10; 1 being the lowest and 10 being the highest. The rating number is multiplied by the weighting factor to determine the value of that firm within the context of each specific factor. Owners can change the level of importance to any of the weighting factors as they see fit depending on how they view the relationship to their project. Additional weighing factors may be added if there are special selection criteria specific to the owner's needs.

**Table 6. Design Team Analysis and Selection Model**

| | | Firm A | | Firm B | | Firm C | | Firm D | |
|---|---|---|---|---|---|---|---|---|---|
| **Weighting Factor[1] (0.5 to 1.5)** | **Weight (a)** | **Rating (b)** | **Score a x b** | **Rating (b)** | **Score a x b** | **Rating (b)** | **Score a x b** | **Rating (b)** | **Score a x b** |
| Building Type Experience | 1.5 | 8 | 12.0 | 6 | 9.0 | 9 | 13.5 | 7 | 10.5 |
| Building Use Experience | 1.3 | 7 | 9.1 | 5 | 6.5 | 8 | 10.4 | 7 | 9.1 |
| Financial Stability | 1.1 | 9 | 9.9 | 9 | 9.9 | 8 | 8.8 | 9 | 9.8 |
| In-House Engineering | 0.8 | 3 | 2.4 | 0 | 0.0 | 2 | 1.6 | 4 | 3.2 |
| Size of Firm | 0.7 | 6 | 4.2 | 6 | 4.2 | 7 | 4.9 | 5 | 3.5 |
| Backlog | 1.4 | 9 | 12.6 | 7 | 9.8 | 5 | 7.0 | 3 | 4.2 |
| LEED Professionals | 0.5 | 0 | 0.0 | 8 | 4.0 | 5 | 2.5 | 3 | 1.5 |
| In-House Consultants | 1.0 | 7 | 7.0 | 8 | 8.0 | 0 | 0.0 | 5 | 5.0 |
| Proximity to Project site | 0.9 | 9 | 8.1 | 9 | 8.1 | 2 | 1.8 | 6 | 5.4 |
| Fee | 1.3 | 1 | 1.3 | 9 | 11.7 | 7 | 9.1 | 3 | 3.9 |
| Hourly Reimbursable Rates | 1.1 | 9 | 9.9 | 1 | 1.1 | 5 | 5.5 | 5 | 5.5 |
| Interview presentation | 1.5 | 8 | 12.0 | 8 | 12.0 | 6 | 9.0 | 7 | 10.5 |
| Completeness of Proposal | 1.4 | 7 | 9.8 | 8 | 11.2 | 9 | 12.6 | 9 | 12.6 |
| Answers to questions | 1.3 | 6 | 7.8 | 5 | 6.5 | 10 | 13.0 | 7 | 9.1 |
| Aggregate Score | - | - | 106.10 | - | 102.00 | - | 99.70 | - | 93.80 |
| Overall Ranking | - | - | **1** | - | **2** | - | **3** | - | **4** |

For purposes of illustration and discussion Table 6 has been filled in with sample values to better help the user visualize the implementation of the selection analysis process and how it works. Owners would not necessarily select the design team with the lowest aggregate score but rather use the entirety of information in the table to make the best decision for their project. The most important benefit of the model is most or all of the owner's goals and objectives can be (or are) represented within the workings of the model.

## CONTRACTOR SELECTION

Contractor selection can be equally as tedious as finding the right design firm. With the competition and number of firms to choose from even greater, the task can seem insurmountable or impossible at first glance. A great way to take the guess work and anxiety out of the contractor selection process is to apply a more objective set of criteria to the selection process as shown in Table 4. Sample values have been inserted to aid the owner utilizing the analysis process to their greatest advantage. Each weighting factor (or selection criteria) has been assigned a weight or value. These values can be changed by each owner as they see fit. As the contractors are being compared and assessed for their capabilities they are rated on a scale of 1-10; 1 being the worst and 10 being the

best. The rating is then multiplied by the weight of the specific criteria to produce a score for the specific criteria. The scores are then added up to produce a total score by which the contractors can be evaluated.

**Table 7. Contractor Analysis and Selection Model**

| | | Firm A | | Firm B | | Firm C | | Firm D | |
|---|---|---|---|---|---|---|---|---|---|
| **Weighting Factor[1] (0.5 to 1.5)** | **Weight (a)** | **Rating (b)** | **Score a x b** | **Rating (b)** | **Score a x b** | **Rating (b)** | **Score a x b** | **Rating (b)** | **Score a x b** |
| Building Type Experience | 1.5 | 9 | 13.5 | 7 | 10.5 | 8 | 12.0 | 8 | 12.0 |
| Building Use Experience | 1.3 | 7 | 9.1 | 8 | 10.4 | 9 | 10.7 | 6 | 7.8 |
| PM Experience | 1.2 | 5 | 6.0 | 9 | 10.8 | 10 | 12.0 | 8 | 9.6 |
| Superintendent Experience | 1.4 | 4 | 5.6 | 7 | 9.8 | 6 | 8.4 | 8 | 11.2 |
| Financial Stability | 1.4 | 9 | 12.6 | 10 | 14.0 | 9 | 12.6 | 9 | 12.6 |
| In-House Scheduling | 0.8 | 10 | 8.0 | 10 | 8.0 | 10 | 8.0 | 10 | 8.0 |
| In-House Estimating | 0.9 | 7 | 6.3 | 9 | 8.1 | 8 | 7.2 | 10 | 9.0 |
| Size of Firm | 1.0 | 8 | 8.0 | 7 | 7.0 | 8 | 8.0 | 7 | 7.0 |
| Backlog | 1.4 | 5 | 7.0 | 6 | 8.4 | 7 | 9.8 | 5 | 7.0 |
| LEED® Professionals | 0.5 | 0 | 0.0 | 5 | 2.5 | 4 | 2.0 | 6 | 3.0 |
| Safety Modifier | 1.5 | 9 | 13.5 | 6 | 9.0 | 7 | 10.5 | 7 | 10.5 |
| Proximity to Project site | 0.9 | 10 | 9.0 | 10 | 9.0 | 7 | 6.3 | 10 | 9.0 |
| Fee | 1.3 | 9 | 11.7 | 8 | 10.4 | 7 | 9.1 | 6 | 7.8 |
| Hourly Reimbursable Rates | 1.1 | 5 | 5.5 | 6 | 6.6 | 7 | 7.7 | 9 | 9.9 |
| Interview presentation | 1.5 | 7 | 10.5 | 7 | 10.5 | 9 | 13.5 | 8 | 12.0 |
| Completeness of Proposal | 1.4 | 9 | 12.6 | 8 | 11.2 | 8 | 11.2 | 9 | 12.6 |
| Answers to questions | 1.2 | 7 | 8.4 | 8 | 9.6 | 7 | 8.4 | 7 | 8.4 |
| Web-Based Management | 0.6 | 9 | 5.4 | 9 | 4.8 | 5 | 3.0 | 6 | 3.6 |
| In-House Commissioning | 1.1 | 3 | 3.3 | 8 | 8.8 | 9 | 9.9 | 6 | 6.6 |
| Ability to Self-Perform | 0.8 | 0 | 0.0 | 0 | 0.0 | 9 | 7.2 | 7 | 7.2 |
| Claims or Litigation | 1.4 | 10 | 14.0 | 2 | 2.8 | 4 | 5.6 | 9 | 12.6 |
| Lean Construction | 0.8 | 5 | 4.0 | 5 | 4.0 | 7 | 5.6 | 4 | 3.2 |
| Aggregate Score | - | - | 174.00 | - | 176.20 | - | 188.70 | - | 190.60 |
| Overall Ranking | - | - | **4** | - | **3** | - | **2** | - | **1** |

*Note to Table: Weighting factor application was selected as an arbitrary range to best illustrate the use of the table. User of this table will determine how each factor is weighted based on its level of importance, where 0.5 = least important and 1.5 = most important*

Table 7 illustrates how an owner might develop an overall ranking of each contractor under consideration. The contractor selection process is similar to the architect selection process in that the Owner can develop specialized criteria unique to their projects and incorporate them into the selection model to produce the most project-specific analysis results. Owners would not necessarily

select the contractor with the lowest aggregate score but rather use the entirety of information in the table to make the best decision for their project.

## PROJECT FINANCING

As with most owners financing a new construction project is critical to the success of their overall operation. The wrong model could put excessive strain on their internal finances and thereby seriously affect other aspects of their operations. To most owners financing of a construction project is a type of business venture out of their normal scope of investment and many times lack the in-house expertise to apply the correct principals associated with the unique nature of construction. For the aforementioned reasons, project financing has to be at the forefront of the inception of any construction project. Without a sound financial model, the project will most likely never get out of the feasibility state. Since construction projects are subject to a wide array of variables not typically associated with other business operations the risk of failure can be higher. Table 6 illustrates the questions the owner should be asking on an internal basis of staff and management. As the model is applied the owner should investigate thoroughly any question which received a "*No*" response as well as follow-up as to the why and if the issue can be corrected in a reasonable manner and timeframe. The owner has more than a responsibility to pay the monthly requisitions; there is an obligation to pay the contractor on time, and there is the responsibility to have made arrangements for financing prior to the start of the construction (Grasso, et al 2008). Developing the appropriate model is much more than having funds on hand to meet those payment requisitions. For most construction projects, the minimal issues that should be addressed, as previously outlined, will adequately protect the Owner in the event the project does not go as planned.

## RECOGNIZING PROBLEM PROJECTS

Many construction projects have problems to one degree or another. Some can be avoided by good project management and some are inevitable such as severe weather. The ability of an owner to identify a problem early on in its inception is vital to the overall success of the project. The following checklist approach defines questions the Owner can ask as part of an internal project audit to more easily detect warning signs for a potentially troubled project they have undertaken. This training strategy model was developed as a result of the literature review and the data collected from the survey instruments. As the model is applied (during pre-construction and during construction) the owner should thoroughly investigate any question which received a "*No*" response as well as follow-up as to the why and if the issue can be corrected in a reasonable manner and timeframe (see Table 8).

**Table 8. Owner's Project Checklist**

| | | |
|---|---|---|
| **Scope** | | |
| Are there numerous disputes between architect and contractor over what is in or out of scope? | □ Yes | □ No |
| Is the number of RFI's unusually high?[1] | □ Yes | □ No |
| Are there numerous change order requests? | □ Yes | □ No |
| Are their numerous scope changes? | □ Yes | □ No |
| **Cost** | | |
| Do the cash flow projections show substantial variances? | □ Yes | □ No |
| Are there numerous cost overruns for individual activities or groups of activities? | □ Yes | □ No |
| Are there frequent project payments late, not being paid, or in dispute? | □ Yes | □ No |

| | | |
|---|---|---|
| **Schedule** | | |
| Is the schedule being updated on a conventional basis? | □ Yes | □ No |
| Is the contractor continuously re-sequencing project tasks? | □ Yes | □ No |
| Have there been a myriad of time extension requests? | □ Yes | □ No |
| Are there numerous activities running late on a consistent basis? | □ Yes | □ No |
| Are there multiple non-conformance or non-compliance notices? | □ Yes | □ No |
| Are there multiple disputes on repairing or replacing of work in place? | □ Yes | □ No |
| **Project Administration** | | |
| Are meeting minutes being kept and are they an accurate record of what took place? | □ Yes | □ No |
| Is there a pattern of un-answered correspondence? | □ Yes | □ No |
| Is the submittal and procurement process meeting the needs of the CPM schedule? | □ Yes | □ No |
| **Physical Worksite** | | |
| Is the site sloppy and trashy, i.e. poor housekeeping? | □ Yes | □ No |
| Is there a lack of work flow between activities? | □ Yes | □ No |
| Are work crews being constantly broken up and reformed? | □ Yes | □ No |
| **Safety** | | |
| Have there been frequent lost-time accidents? | □ Yes | □ No |
| Have there been frequent reportable incidents? | □ Yes | □ No |
| Is there a lack of or limited use of personal protective equipment? | □ Yes | □ No |
| Is the safety plan project specific? | □ Yes | □ No |
| **Design Changes** | | |
| Are there numerous clarifications issued by the A/E? | □ Yes | □ No |
| Are there numerous conflicts between the plans and specs? | □ Yes | □ No |
| **Project Financing** | | |
| Is the project financing mechanism independent of other aspects of your business financial operations? Should it be? | □ Yes | □ No |
| Do the pre-project cash flow projections focus on the likely billings and expenditures of the design and construction activities? | □ Yes | □ No |
| Does the internal cash flow or construction loan formula support the pre-project cash flow projections? | □ Yes | □ No |
| Are their monthly retainage requirements written into the contractual agreement that protect you in the event of non-conforming work? | □ Yes | □ No |
| Does the project financing model adequately address the projects' unique financial risks such as unique design, compressed schedule, time of year, etc.? | □ Yes | □ No |
| Are detailed and proven written contracts such as AIA being used to protect your interests? | □ Yes | □ No |
| Have you considered the use of bonds such as performance and/or material payment to protect your interests in the event of contractor(s) failing to meet their contractual requirements? | □ Yes | □ No |
| Is there a system of checks and balances in place to verify the work performed is approximately equal in value to the amount being billed in any given billing cycle? | □ Yes | □ No |
| Were financial background checks conducted on the design team and key contractors? | □ Yes | □ No |
| Are there numerous disputes between architect and contractor over what is in or out of scope? | □ Yes | □ No |

*Note to Table*

*RFI = request for information is a procedure by which a contractor or bidder can request clarification from the architect or engineer in instances where there is conflicting or missing information in the plans and/or specifications as well as any other contract documents that have been provided*

Although the Owner generally relies on the design and construction professionals they have retained to foresee problems it is in their best interests to develop an internal ability to detect subtle performance indicators that a given project may be in trouble.

## TRAINING STRATEGY FOLLOW-UP

Once the training strategy models were fully developed they were presented to one owner from each of the three types via a short phone interview. In the case of Type 1 & 2 owners they commented that training strategies such as the ones developed in the research would have been very helpful past projects so much so that they most certainly be utilized on future construction projects. The Type 3 owner viewed the training strategy models and the research process as an '*eye-opening*' experience and commented it will be a valuable tool going forward for them to utilize as they plan their first project. Another significant benefit that owners could gain from this type of training strategies could be they would not have to invest in hiring additional consultants to assist them in offsetting any negative impacts that could result from the four major areas of concern outlined in this research.

## CONCLUSIONS AND RECOMMENDATIONS

Construction owners face a multitude of challenges and opportunities when entering into a new construction project. For the most part they are unaware of the multitude of pitfalls that can influence their construction projects. The following conclusions have been developed as a result of the research:

- Owners could implement some sort of analysis metrics similar to Table 7 to select or filter their choices for both the design and construction professionals
- All levels of owners from the very experienced to the novice will most likely encounter some level of obstacles on their projects if not fully prepared
- Becoming educated on the many unique characteristics of the design and construction process will provide the Owner with the necessary tools to ensure project success. Reliance alone on the design team and constructors to achieve the project-specific goals and objectives is not enough and should be augmented with acquiring training for their in-house personal prior to the start of the entire process.

The following items could be explored as a follow on to this research:

1. Ask owners to rank the major areas of concern in order of importance
2. Expand the owner training aspect to focus on more important areas of concern as identified by the respondents
3. Collect data from a wider range of construction owners such as commercial and industrial
4. Develop an on-line training guide which subscribing owners could access at any time.

The site would need to be tailor able to each owner's individual needs as they saw fit.

5. Develop a training seminar which owners or their designated representative could attend and receive direct training
6. Develop a training guide that could be marketed or introduced to owner groups as a guide for them to refer to prior to starting the next building project.

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## APPENDIX A – SAMPLE OF SURVEY DOCUMENT

Question #1 asked the respondents to indicate their alignment with the statement: "As the owner we feel we are adequately prepared prior to venturing into our construction projects"

| Strongly Agree | Agree | Undecided | Disagree | Strongly Disagree |
|---|---|---|---|---|
| 5 | 4 | 3 | 2 | 1 |

Question #2 asked the respondents to indicate their alignment with the statement: "Training for in-house staff is an important investment that would significantly enhance the success of the project"

| Strongly Agree | Agree | Undecided | Disagree | Strongly Disagree |
|---|---|---|---|---|
| 5 | 4 | 3 | 2 | 1 |

Question #3: What are the major areas of concern (issues) you have encountered as a construction project owner that you felt you were ill-prepared to address and felt additional training would have helped in the management of those issues?

# Perceptions of Remote Work within the Construction Industry Resulting from the COVID-19 Pandemic in the South Central United States

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## Abstract

*Working remotely became increasingly popular over the previous two years, given organization's need to rapidly adjust to changing conditions as a result of the Coronavirus. It allowed companies to more easily adapt to stay-at-home orders and create a safer environment for their employees. While working remotely can have a positive impact on employees, there are also challenges to overcome for both employees and organizations. This study focused on understanding both the prevalence and implementation of remote work within the commercial Construction industry to face the professional challenges resulting from the Coronavirus. This paper provides insight into companies that have implemented remote work procedures as well as the positive or negative experiences from both an employee and managerial perspective. Through descriptive statistics and t-tests, the findings suggest that employees have strong positive and negative perceptions of remote work whereas managers have little if any positive perceptions. Furthermore, when comparing pre-construction and operations, employees within these two departments have statistically different perceptions as well.*

***Key Words:*** *Coronavirus; Remote Work; Construction;*

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## Introduction

The emergence of the novel Coronavirus (SARS-CoV-2) in the United States, in the Spring of 2020, has created an unprecedented impact on people's personal and professional livelihoods. In order to maintain employee productivity and allow businesses to continue to survive, companies across all industries have been forced to adapt to rapidly changing conditions. As such, there has been a tremendous increase in the implementation of remote work procedures. According to the July 2020 Jobs Report released by the U.S. Bureau of Labor Statistics, an estimated 26.4% of employees were teleworking due to the Coronavirus pandemic (U.S. Department of Labor, 2020). As of the January 2021 Jobs Report, that number had decreased only slightly to 23.2% of employed persons teleworking (U.S. Department of Labor, 2021).

On January 7, 2020, Chinese researchers announced the discovery of the novel Coronavirus in Wuhan, China. By February, the Centers for Disease Control and Prevention (CDC) had confirmed the first instances of community spread in the United States, and by Mid-March, the United States had declared a national emergency (Council of Economic Advisers, 2020). According to the CDC, between March 1st and May 31st, 42 states and territories issued mandatory stay-at-home orders, affecting 73% of all U.S. counties (Moreland, Herlihy, Tynan, et. al, 2020). In order to continue moving forward on projects and pursue future work, construction companies were forced to re-imagine their work environment, especially given that different states had different guidelines; for example, construction was considered essential business in Texas and Oklahoma whereas it was shut down entirely in Pennsylvania and New York (Dodge Research, 2020).

In a survey completed among over 400 Architecture, Engineering, and Construction companies, 71% of companies reported eliminating face-to-face meetings and nearly half of the companies reported either allowing or requiring their employees to work from home (Grinapol & Blair, 2020). Both men and older employees tend to view working remotely more negatively (Raisiene, Rapuanu, Varkuleviciute, & Stachova, 2020). In an industry that is over 90% male (Perrenoud, Bigelow, and Perkins, 2020), and has continued to see an increase in the average age of workers (Schwwatka, Butler, & Rosecrance, 2012), the ways that companies have adapted due to the Coronavirus pandemic may be different than other industries and, as a result, may not lead to long-term changes in the construction industry.

With that in mind, the goal of this research was to explore the state of the construction industry as it pertains to remote work in early 2021. Specifically, the authors sought to answer four main questions:

- How prevalent is remote work and would employees, regardless of whether they have direct reports, like for their companies to retain remote work procedures when the situation allows for a return to normal working conditions?
- What are the positive and negative perceptions of remote work for employees?
- What are the positive and negative perceptions of remote work for managers?
- How are the perceptions of professionals in pre-construction and operations different?

This study is significant as it helps to establish a baseline on how the use of remote work has altered working conditions within the construction industry. Understanding these perceptions will play an important role in organizational development for construction companies into the future.

## Review of Literature

While the Coronavirus has accelerated the growth of remote work substantially, there was already growing popularity in this area within the United States. Between 2005 and 2017, the U.S. saw a 115% growth in working from home (Razif, Miraia, Persada, et al., 2020). A review of the literature explored the broad nature of remote work as well as the impact that the Coronavirus has had on the work environment overall. However, no academic articles investigating remote work specifically within the construction industry could be found. The only available literature identified was published through online news publications, and thus not peer reviewed. This study begins to fill the gap in the body of knowledge on the subject of remote work in construction while also acknowledging the role of the Coronavirus as a catalyst that forced organizations to adopt remote work strategies.

### Remote Work Procedures Overview

Working remotely can take on a variety of forms; although there is no universally accepted definition, the International Labour Organization defines telework as the use of information and communication technologies for work that is performed outside of the employer's main location (Messenger, 2017). Remote work generally takes on one of three different forms: (1) from home at least several times per month; (2) at least several times per week in at least two locations other than the employer's main location; (3) less frequently or at fewer locations than the other two options (Belzunegui-Eraso & Erro-Garces, 2020). In a review of data from the Occupation Information Network and U.S. Bureau of Labor Statistics, it was estimated that within the United States, 37% of jobs, accounting for 46% of all wages, could be performed entirely at home. Yet, a review of the 2018 American Time Use Survey found that less than 25% of full-time employees work from home on an average day, and even those workers spend less than half of their working hours at home (Hicks, 2020).

Previous research has identified several areas where working remotely is more advantageous than a traditional work environment, both for employers and their employees. According to a survey completed in 2019 by Airtasker, telecommuters averaged 1.4 more days of work every month, or 16.8 days every year, over their in-office counterparts (Caramela, 2020). In addition to this increase in working time, a survey of nearly 400 workers found that those who work remotely have both a stronger organizational commitment and a lower turnover rate (Golden, 2006). Furthermore, working remotely allows employers to attract and hire employees from anywhere in the world and extend company operations to a 24-hour work day. Working remotely also benefits employees, giving them greater independence and flexibility over working time and place. Additionally, it also saves employees time by reducing or eliminating commuting time and allows employees to maintain better health and productivity (Raisiene, Rapuanu, Varkuleviciute, & Stachova, 2020). Carmela (2020) found that employees who work remotely save an estimated $4,500 per year on fuel and spend an additional 25 minutes per week exercising.

Studies among employees regarding remote work have also revealed several drawbacks. According to the Airtasker survey, 29% of participants reported they had a hard time maintaining a healthy work-life balance as compared to 23% of office workers. On top of that, approximately half of those surveyed felt overly stressed and anxious during the work day and more than a third procrastinated on a task until its deadline, all of which outpaced their office counterparts (Caramela, 2020). Furthermore, Raisiene, et al. (2020), found that working remotely tends to be viewed more negatively by both men and older workers, given their feelings that there are more distractions by other members of the household and more difficulties related to self-organization and work accomplishment. This is especially challenging in the construction industry given

that the industry is dominated by both of these demographics. The average age of workers in the construction industry is rising, increasing from 37.9 years in 2000 to 40.4 years in 2010 (Schwatka, Butler, & Rosecrance, 2012). Additionally, construction-related jobs are on average 98% male and considered among the most male-dominated occupations (Catalyst, 2013).

**Coronavirus & Remote Work Procedures**

The Coronavirus has rapidly transformed both how and where people work (Bynjolfsson, et. al (2020). A Pew Research Center analysis found that the number of adults between 18-64 who reported they were working from home as a result of the Coronavirus by late March was nearly 40% (Kochhar & Passel, 2020). A survey of more than 300 CFOs revealed that nearly 75% will move at least 5% of their previously on-site workforce to remote positions permanently, with nearly a quarter of participants saying they will move at least 25% of their workforce to remote positions (Goodman, 2020). Yet, a study conducted in April and May 2020 of more than 25,000 participants found a significant geographic variation among the impact of the Coronavirus. Those in the U.S. South showed substantially lower levels of remote work and higher levels of commuting than their counterparts in the U.S. Northeast (Brynjolfsson, Horton, Ozimek, Rock, et.al, 2020).

Of those companies that have increasingly introduced remote work procedures, a majority are large or multinational, and had Human Resource professionals on company disaster planning committees (Belzunegui-Eraso & Erro-Garces, 2020). Many of those companies already had work-from-home procedures in place. They simply expanded them to all personnel and provided additional software and hardware for their employees in response to the Coronavirus.

**Coronavirus & Remote Work Procedures in the Construction Industry**

As previously stated, no peer-reviewed publications regarding the impact of the Coronavirus on the use of remote work within the construction industry could be found; however, several news publications and organizations have conducted surveys among their readers and published the results. The Associated General Contractors of America conducted a survey in both March and April to better understand how the industry had been impacted. Among their members, 53% reported that project owners had halted or canceled current projects as a result of deteriorating economic conditions; in addition, nearly 40% of firms were forced to lay off employees (The Associated General of America, 2020). Of those employees who were able to continue working, many had to adjust for alternate work environments. A survey completed by Clear Skies Research, the parent company of Engineering News-Record, found that more than 40% of the companies who responded were requiring their employees to work from home by the end of March. In addition, nearly a third of employers reported they were more focused on investigating new technologies for their business today than they were six months ago (Grinapol & Blair, 2020).

In response to the Coronavirus, the implementation of remote work has seen a dramatic increase. Although there is debate over whether working remotely is more or less beneficial than working in a traditional office environment, feedback from company executives illustrates that this shift could be permanent. This change in work environment extends to all industries within the United States, including the construction industry. There is a lack of knowledge regarding the use of remote work procedures within the construction industry. As such, the purpose of this study is to understand the level at which remote working procedures are being implemented and their overall perception among construction professionals.

## Methodology

This was an exploratory study that sought to identify influential factors. The data sample was collected using a Likert scale survey. Specifically, participants were asked to provide their perceptions on remote work as it related to 19 factors identified in the literature. Similar to a study completed by Raisiene et. al (2020), online survey responses were collected from both Pre-Construction and Project Management professionals. The two groups were targeted given their needs would vary when working remotely as a result of their job roles and responsibilities. The goal was to better understand both the positive and negative perceptions of working remotely among these two functional areas.

On average, the survey required less than 15 minutes for all participants to complete. Participation was initially solicited from members of the Associated Builders and Contractors of Central Texas, TEXO, and the Associated General Contractors of Oklahoma who were general contractors. However, following the initial solicitation, snowball sampling was used as participants were encouraged to share the survey link with their networks. Multiple employees within a specific company were able to participate in the study; however, no single company represented more than 13% of the survey responses. This study was delimited to commercial general contractors operating in North Texas, Central Texas, and Oklahoma. As a result, generalization beyond this region should be done with caution.

The survey items were focused on perceptions regarding remote work. Demographic questions were also included to better understand survey participants and to make comparisons. To mitigate threats to internal validity, the survey was beta tested and then reviewed by a focus group.

The survey asked participants to rate their perceptions of the different factors related to remote work on a Likert scale as follows: 4 = “Extremely Positive”, 3 = “Somewhat Positive”, 2 = “Somewhat Negative”, 1 = “Extremely Negative”. Participants were also able to answer “Does Not Apply”. The “Does Not Apply” responses were not coded with a value and were excluded from the mean calculations. Respondents who were not working remotely were not included in the analysis. Descriptive and inferential statistics were used primarily to describe the sample, while inferential statistics were used to compare the groups and draw conclusions.

## Results and Discussion

A total of 163 responses, representing 40 different companies, were received. A filtering process removed 20 of those responses (three chose not to participate and 17 surveys were incomplete) leaving 143 responses. An additional 40 responses were filtered out as they came from individuals not currently working remotely. The resulting final sample for analysis consisted of 103 complete responses.

As can be seen in Figure 1, the location breakdown of the 103 responses was split fairly evenly between Texas (North and Central) and Oklahoma. Three participants did not specify their work location and their responses represent “Other” in Figure 1.

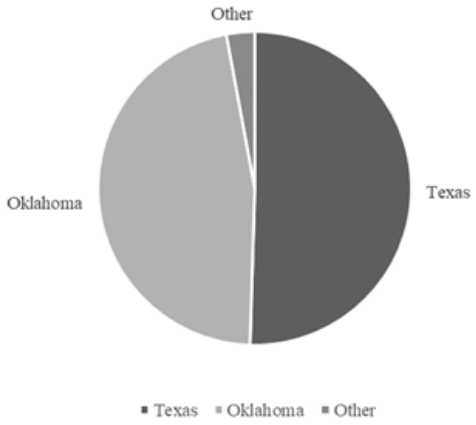


**Figure 1. Participant Location**

Nearly 83% of participants were male; thus, female participants were more highly represented in the sample than in the industry as females only make up about 10% of the construction industry overall. The overwhelming majority (87.5%) had at least a Bachelor's Degree and there was a broad range of industry experience. Nearly three quarters of the sample had 10 or more years of experience. Figure 2 illustrates the breakdown of participant experience in the sample.

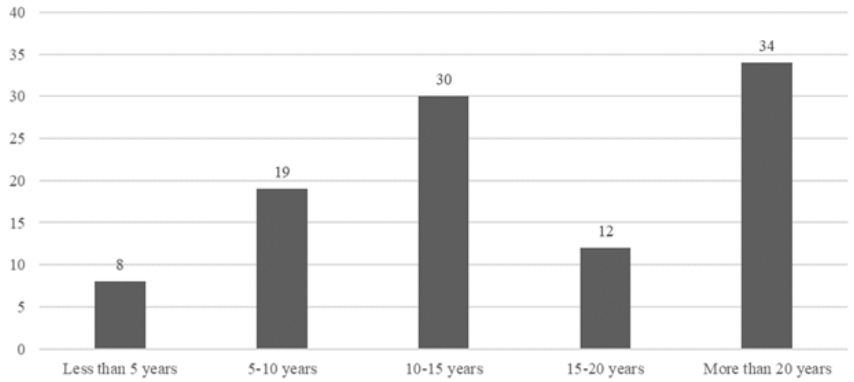


**Figure 2. Work Experience of Participants**

Of the companies represented in the sample, a majority (70%) had an annual revenue of more than $100 million. Figure 3 displays the revenue distribution of the participants' companies.

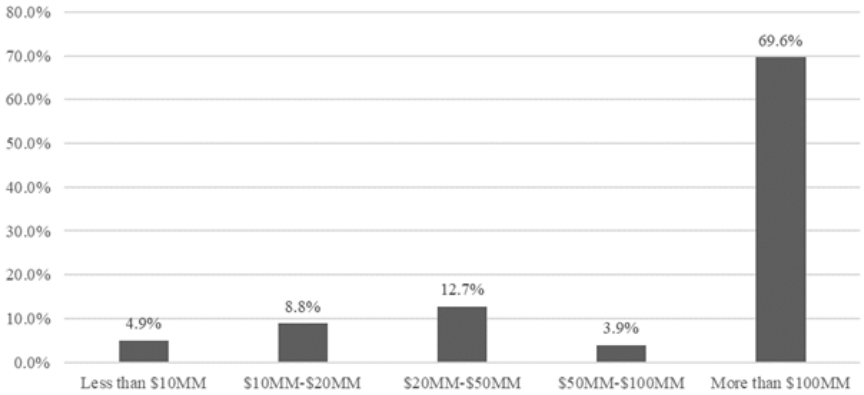


**Figure 3. Annual Company Revenue of Participants**

The majority of participants worked in a Project Management type role. Figure 4 shows the job-type breakdown, with nearly three-fourths working in Operations. This breakdown of operations vs. pre-construction likely over represents pre-construction professionals as construction companies typically have considerably more operations employees than pre-construction employees. Beyond the classifications of operations and pre-construction, nearly two-thirds (74) of participants reported that they are office based rather than site based (29).

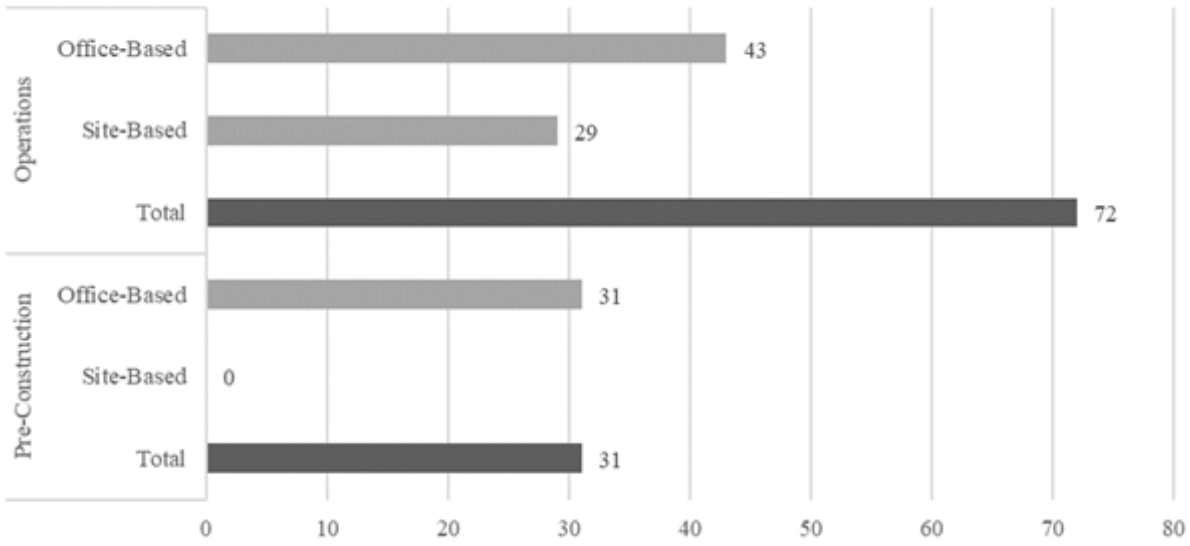


**Figure 4. Job Role and Work Location of Participants**

Despite a majority of employees being based on-site, a similar number of participants (72) did report having a dedicated office area at home to work from. This could have created an easier transition into working from home and thus, a more improved experience overall. That being said, nearly 70% of those with dedicated home offices were in Operations-based roles, which would require them to be on-site. Beyond that, more 60% of participants who had dedicated home offices also reported having children living at home with them, which could have a negative implication given the remote learning environment that many schools implements across Oklahoma and Texas.

Regarding the first research question: *How prevalent is remote work and would employees like for their companies to retain remote work procedures when the situation allows for a return to normal working conditions?* Over 72% of participants (103 out of 143) reported they were currently working remotely in some capacity, yet only 43% wanted to continue doing so. While the inability to be physically on a job site and oversee progress may have contributed to this response, the combination of personal and professional isolation created by the Coronavirus pandemic may also be a factor. Many of these remote work procedures were a result of the ongoing pandemic, as less than 18% of participants reported working remotely prior to the onset of the Coronavirus.

The next research question was: *What are the positive or negative perceptions for employees?* The most overwhelmingly positive perception was in regard to the reduction in "commuting time", with 90 of the 103 participants responding positively (76 extremely positive, 14 somewhat positive) to this question. Consistent with previous research on remote work, employees also

had positive perceptions of being able to "choose their own work place" and "choose their own work time". Beyond these, seven other factors had mean scores above three, indicating positive perceptions by employees. These results are displayed in Table 1 below.

Eight factors had mean scores below three, indicating a negative perception of these elements while working remotely. The factor with the most negative response was "workplace unity". Additionally, the ability to both "communicate with other employees and/or trade partners" as well as the ability to "build trust within workplace relationships" had the lowest mean scores. These results suggest that the construction industry is consistent with other industries in their perceptions of the pros and cons of remote work.

**Table 1. Participants' Perceptions of Working Remotely (Employees)**

| Rank | Factor | N | Mean | Standard Deviation |
|---|---|---|---|---|
| 1 | Commuting Time | 94 | 3.78 | 0.48 |
| 2 | Choosing your Work Time | 89 | 3.44 | 0.62 |
| 3 | Choosing your Work Place | 95 | 3.41 | 0.64 |
| 4 | Commitment to Organization | 93 | 3.37 | 0.73 |
| 5 | Work and Personal Life Balance | 97 | 3.30 | 0.77 |
| 6 | Organizing your Work | 93 | 3.26 | 0.69 |
| 7 | Working Individually | 95 | 3.23 | 0.83 |
| 8 | Unnecessary Interactions | 95 | 3.16 | 0.88 |
| 9 | Other Household Members | 87 | 3.14 | 0.86 |
| 10 | Health and Wellness Programs | 85 | 3.09 | 0.81 |
| 11 | Access to Work-Related Information | 94 | 2.99 | 0.87 |
| 11 | Performance Feedback | 82 | 2.99 | 0.71 |
| 13 | Identifying Start and End Point of Tasks | 90 | 2.98 | 0.71 |
| 14 | Interactions with Colleagues and/or Managers | 96 | 2.92 | 0.84 |
| 15 | Required Interactions | 96 | 2.88 | 0.82 |
| 16 | Building Trust with Other Employees/Manager | 95 | 2.83 | 0.82 |
| 17 | Communication with Other Employees/Trade Partners | 96 | 2.62 | 0.86 |
| 18 | Workplace Unity | 98 | 2.51 | 0.91 |

Beyond the exploration of employee's perspectives, this study also sought to understand the perspectives of managers asking: *What are the positive or negative perceptions for managers?* Of the 103 survey participants who reported working remotely, 72 had employees that they managed. Despite the overall positive responses to the set of questions for employees, managers were not as strongly positive towards any of the factors presented to them. Six factors had mean scores greater than three, but none were higher than 3.16. The variables that were viewed most favorably among managers were "reduction in operation costs" as well as the impact working remotely had on the "company image". Managers also felt positively about "staff turnover", which is consistent with previous research (Golden, 2006). Of the remaining experiences asked about in the survey, the one that was perceived most negatively was "training for employees". Managers also felt negatively towards "oversight of employees" working remotely. Table 2 displays the full results for this question.

**Table 2. Participants' Perceptions of Working Remotely (Managers)**

| Rank | Experience | N | Mean | Standard Deviation |
|---|---|---|---|---|
| 1 | Operation Costs | 59 | 3.16 | 0.78 |
| 1 | Company Image | 61 | 3.16 | 0.63 |
| 3 | Staff Turnover | 49 | 3.15 | 0.79 |
| 4 | Data Security | 56 | 3.10 | 0.75 |
| 5 | Employee Satisfaction | 71 | 3.03 | 0.68 |
| 6 | Company Communications | 67 | 3.01 | 0.80 |
| 7 | Employee Efficiency | 71 | 2.96 | 0.72 |
| 8 | Availability of Staff Support | 68 | 2.91 | 0.84 |
| 9 | Company Culture | 67 | 2.81 | 0.86 |
| 10 | Impact on Project Costs | 51 | 2.75 | 0.88 |
| 11 | Oversight of Employees Working Remotely | 70 | 2.56 | 0.79 |
| 12 | Training for Employees | 66 | 2.27 | 0.85 |

Only nine of the 72 managers surveyed were female and only eight managers had been in the industry fewer than 10 years. Nearly half (43%) had been in the industry more than 20 years. These factors could negatively impact managers' perceptions of working remotely as the literature indicates that employees who are both older and male tend to view working remotely more negatively (Raisiene, Rapuanu, Varkuleviciute, & Stachova, 2020).

The final research question posed was: *How are the perceptions of pre-construction and operations employees different?* A statistically significant difference was found among pre-construction and operations employees on three factors: "interactions with colleagues and managers", "building trust with other employees and managers", and "health and wellness programs". Pre-construction employees (M=3.14, SD=.975) reported a significantly more positive outlook towards "interactions with colleagues and managers" than their operations counterparts (M=2.82, SD=.815), t (94) = -1.71, p=.090. With regards to "building trust with other employees and managers", pre-construction (M=3.07, SD=.781) also felt more positive towards working remotely than operations employees (M=2.74, SD=.822), t (93) = -1.84, p=.069. Finally, pre-construction employees (M=3.44, SD=.712) rated "health and wellness programs" more positively than operations (M=2.95, SD=.811), t (83) = -2.63, p=.010. Interestingly, this trend of pre-construction employees feeling more positively towards working remotely was carried throughout all remaining factors, with the exception of "organizing their work". Pre-construction employees felt more negatively (3.21) towards this than operations employees (3.28), though the difference was not statistically significant. Table 3 shows these comparisons between pre-construction and operations employees. Although there were differences on all variables, most were not statistically significant.

**Table 3. Independent Samples t-tests Comparing Pre-construction and Operations Employee's Perceptions of Working Remotely**

| Factor | t | p-value | Mean Difference |
|---|---|---|---|
| Health and Wellness Programs | -2.63 | .010** | -.490 |
| Building Trust with Employees/Manager | -1.84 | .069* | -.339 |
| Interactions with Colleague/Manager | -1.71 | .090* | -.317 |
| Other Household Members | -1.53 | .129 | -.311 |
| Unnecessary Interactions | -1.49 | .138 | -.297 |
| Commitment to Organization | -1.48 | .143 | -.243 |
| Required Interactions | -.918 | .361 | -.169 |
| Workplace Unity | -.692 | .491 | -.140 |
| Work and Personal Life Balance | -.673 | .503 | -.115 |
| Working Individually | -.610 | .543 | -.113 |
| Access to Work-Related Information | -.426 | .671 | -.084 |
| Choosing Work Time | -.469 | .640 | -.066 |
| Communication with other Employees/Trade Partners | -.298 | .767 | -.058 |
| Commuting Time | -.514 | .609 | -.056 |
| Identifying Start/End Point of Tasks | -.305 | .761 | -.050 |
| Performance Feedback | -.272 | .787 | -.046 |
| Choosing Work Place | -1.59 | .116 | -.023 |
| Organizing Work | .400 | .690 | .063 |

*Significant at the 0.1 level

** Significant at the 0.05 level

After addressing the stated research questions, the authors recognized additional comparisons that may be of value related to the question of remote work in the construction industry. Specifically, the comparison of perceptions based on company size as well as the comparison based on office versus field-based personnel. Those comparisons are detailed in the following paragraphs. However, it should be noted that the sample size (n) for companies with revenue less than $100 million and employees who were site-based were both less than 30. According to Gliner, Morgan, and Leech (2009), a minimum of 30 is needed for a comparison of groups. As such, this threat to validity should be considered with these results.

Analysis of the differences between companies with more than $100 million and less than $100 million in revenue revealed a statistically significant difference between the groups regarding "interactions with colleagues and managers", "workplace unity", and "communication with other employees and/or trade partners". Employees of companies earning less than $100 million in annual revenue (M=3.21, SD=.686) had a more positive outlook towards interactions with colleagues and managers than companies with more than $100MM in annual revenue (M=2.79, SD=.873), t (94) = -2.27, p=.015. Although there was a difference regarding "workplace unity" and "communication with other employees and/or trade partners" based on revenue, both groups viewed these variables negatively. Employees of companies earning more than $100MM in revenue (M=2.40, SD=.910) had a more negative view than companies earning less than $100MM in revenue (M=2.76, SD=.872), t (96) = -1.81, p=.073 regarding "workplace unity". Companies earning more than $100MM also felt more negatively (M= 2.51, SD=.853) towards "communication with other employees and/or trade partners" than companies earning

less than $100MM (M=2.89, SD=.832), t (94) = -2.03, p=.045. Given that larger companies would be more likely to have resources in place to more effectively transition to a remote work environment, it was unexpected that they would rate their experiences significantly more negative than their counterparts at smaller companies. Table 4 displays the complete results of the comparison between companies based on revenue.

**Table 4. Independent Samples t-tests Comparing Experiences Working Remotely based on Annual Revenue (<$100MM n= 24-29; >$100MM n= 58-69)**

| Factor | t | p-value | Mean Difference |
|---|---|---|---|
| Interactions with Colleague/Manager | -2.27 | .015** | -.420 |
| Communication with other Employees/Trade Partners | -2.03 | .045** | -.386 |
| Workplace Unity | -1.81 | .073* | -.360 |
| Other Household Members | -1.59 | .115 | -.327 |
| Access to Work-Related Information | -1.34 | .183 | -.262 |
| Building Trust with Employees/Manager | -1.26 | .209 | -.235 |
| Choosing Work Time | -.634 | .528 | -.090 |
| Unnecessary Interactions | -.448 | .656 | -.090 |
| Performance Feedback | -.271 | .787 | -.046 |
| Required Interactions | -.202 | .840 | -.038 |
| Choosing Work Place | -1.76 | .861 | -.026 |
| Organizing Work | -.167 | .868 | -.026 |
| Identifying Start/End Point of Tasks | -.144 | .886 | -.024 |
| Commitment to Organization | .072 | .942 | .012 |
| Health and Wellness Programs | .103 | .918 | .020 |
| Work and Personal Life Balance | .482 | .631 | .082 |
| Commuting Time | .995 | .323 | .110 |
| Working Individually | .726 | .469 | .135 |

*Significant at the 0.1 level

** Significant at the 0.05 level

There were a number of differences between employees who worked in their main office location and employees who officed on a specific job site. In all instances, employees who were located in their main office had a more positive perception of working remotely than their job site counterparts. The most notable differences included employees' perception of "unnecessary interactions", "interactions with a colleague and/or manager", "health and wellness programs", "identifying start and end point of tasks", and "other household members". These results were not surprising, given the nature of on-site construction work. Some tasks simply cannot be addressed remotely. Table 5 shows the full results of the comparisons of employees working in a main office with those working on a job site.

**Table 5. Independent Samples t-tests Comparing Experiences Working Remotely by Working Location (Office Based n= 58-70; Site Based n= 22-28)**

| Factor | t | p-value | Mean Difference |
|---|---|---|---|
| Health and Wellness Programs | 3.19 | .002** | .584 |
| Choosing Work Time | 2.81 | .006** | .408 |
| Interactions with Colleague/Manager | 2.58 | .011** | .473 |
| Building Trust with Employees/Manager | 2.60 | .011** | .470 |
| Other Household Members | 2.30 | .024** | .466 |
| Organizing Work | 1.11 | .272 | .408 |
| Unnecessary Interactions | 1.86 | .066* | .365 |
| Required Interactions | 1.91 | .060* | .345 |
| Commitment to Organization | 2.03 | .046** | .339 |
| Identifying Start/End Point of Tasks | 1.79 | .078* | .295 |
| Choosing Work Place | 1.89 | .062* | .271 |
| Workplace Unity | 1.12 | .266 | .231 |
| Work and Personal Life Balance | 1.07 | .285 | .189 |
| Communication with other Employees/Trade Partners | .843 | .402 | .164 |
| Access to Work-Related Information | .483 | .630 | .097 |
| Working Individually | .237 | .813 | .046 |
| Commuting Time | .364 | .717 | .041 |
| Performance Feedback | .080 | .932 | .014 |

*Significant at the 0.1 level

** Significant at the 0.05 level

## Conclusion

Overall, this study created a foundation for understanding the prevalence of remote work as well as the positive and negative experiences of remote work among employees in the commercial construction industry, specifically in Texas and Oklahoma. Although certain takeaways reinforced previous research, the construction industry overall varies from other industries in that it requires greater face-to-face interactions among project team members and between general contractors and their trade partners.

Given the extended period of time that workers remained at home due to state-wide regulations, the Coronavirus pandemic has illustrated that an extended remote work environment is possible within the construction industry. More than 40% of employees surveyed in December 2020 indicated that they would like to remain working in a remote environment. As such, companies must continue to invest in both technology and training even after employees begin to return to the office full-time. This will allow continued flexibility for employees to choose their own work time and work place when the situation allows. For example, companies who introduce a more flexible work environment can more easily address summer and holiday schedules to reduce time employees may need to take away from this office. This will allow for better coverage for construction projects while allowing employees the freedom they need in their personal and professional lives. Additionally, companies who continue to invest in their remote work procedures will be better prepared to respond to future epidemics, or as we have seen over

the previous two years different variants within the ongoing Coronavirus pandemic, as well as other business interruptions such as severe weather. This will ultimately lead to a better overall experience for both the employee and the company.

Furthermore, this study has shown, there is also a wide divergence between pre-construction and operations regarding their perception of working remotely. This presents further opportunity for senior management to establish alternative work procedures for both groups. Rather than applying one overarching policy to the entire company, pre-construction could be allowed to continue working remotely indefinitely while operations could begin a tiered return to work as detailed above. This is especially enticing given pre-construction employees felt positively towards building trust with their employees and/or manager as well as interactions with their colleagues and/or manager whereas operations employees rated these negatively. In allowing for two different paths, companies can continue to enhance their image while also reducing staff turnover.

As the title of this paper suggests, this study was conducted to identify perceptions of remote work in the pandemic environment of 2020. however, the pandemic is ever-evolving and further research will be prudent to understand the long-term impacts and employee needs in a post-herd immunity environment. As companies return to an environment that can allow for an increase in face-to-face communication and reduction in social distancing, management will need to understand the benefits and costs of remote work and select the best approach for their individual projects and their employees overall.

## Future Research

Future research will be vital in order to further the understanding and long-term impacts that the Coronavirus has had on the construction industry. As the data of this study has shown, less than half of employees (43%) wished to remain in a remote work environment. Although this could be due to the overall isolation caused by the Coronavirus as well as the expedited and likely unplanned move to working remotely, further investigation is needed to understand employees' desire to return to normal working conditions. As stated above, more than two-thirds of employees had a dedicated home office; however, the majority of those with a home office either had a site-based role as well as kids living at home. While having a dedicated workspace could create a smoother transition to remote working, the need to be on-site or overall increased distractions could have also had a negative affect. Further research would be beneficial to understand how the perceptions of remote working have changed as stay-at-home orders and general isolation have continued to evolve.

Further research could also be used to understand if approaches to remote work in other industries could be adapted to provide a more beneficial experience for employees and their managers in the construction industry, specifically. There also needs to be further investigation into why managers did not feel overly positive towards any of the experiences provided in the survey. Given this study provided pre-determined answers based on previous research, additional exploration may be able to identify alternative experiences that managers feel more positively towards in a remote work environment. This would also provide an opportunity to better understand whether their perception of working remotely being overall negative is a result of tangible impacts they have seen on their employee's work or simply their own feelings toward remote work.

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# Impact of COVID-19 on Sense of Community / Student Engagement

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## ABSTRACT

*The spring of 2020 was a time of unprecedented change for higher education institutions. The COVID-19 pandemic forced schools to re-think instructional delivery and the undergraduate experience as they implemented measures to protect students, faculty, and staff. Unraveling the impact of the pandemic on higher education will take many years. This study investigated how the institutional response in the return to campus following the pandemic influenced sense of community, a component of student engagement. A previously developed instrument was delivered at two construction management programs in the U.S. Midwest before and after the pandemic. The two schools were similar in many ways, yet they implemented different responses to the pandemic. Despite their similarities, one school experienced lower sense of community following the return to campus in the fall of 2020 while the other school reported no change. The results of this study should serve to both document the impact of the COVID-19 pandemic and guide strategies to protect student engagement when addressing similar challenges in the future.*

**Keywords:** Pandemic, Sense of Community, Construction Education.

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## INTRODUCTION

The COVID-19 pandemic had a significant impact on higher education across the United States. In an effort to protect students, faculty, and staff, most institutions abruptly transitioned to online instructional delivery, closing down the traditional college campus midway through the spring of 2020. With the introduction of social distancing, personal protective equipment, readily available testing, contact tracing, and an effective vaccine, some colleges began the transition back to a more traditional campus environment in the fall of 2020.

In the wake of the pandemic higher education institutions are seeking to understand the impacts on their students. Of primary importance is understanding the impact on learning in light of course schedule interruptions and the rapid shift to online delivery. Another unknown that is related to the learning experience is the impact of the pandemic on student engagement.

While the pandemic was disruptive for scholars and research projects in progress, it also presented new opportunities. Prior to the shutdown, the researchers had initiated data collection efforts in undergraduate construction management programs in the U.S. Midwest. The intent of the study was to measure and compare sense of community (SOC) of women and racial minorities to the dominant demographic of white males. Data collection was completed at two schools prior to the shutdown. While the initial study was temporarily halted, the opportunity emerged to compare SOC before and after the pandemic at the two schools.

The results of the SOC instrument present a measure of psychological/emotional engagement or sense of belonging, which is one component of student engagement. The revised focus and purpose of this study was to investigate SOC before and after the COVID-19 pandemic at two Midwestern construction management programs. This study explores the impact of the differing institutional responses in the return to campus on SOC. The findings should be used to guide educational leaders as they prepare future responses to similar challenges.

## LITERATURE REVIEW

COVID-19 forced unprecedented change onto universities in the United States and around the world. While still in its infancy, pandemic related research is beginning to explore the impact on students, faculty, and higher education institutions. The focus of the literature presented here are elements of the student experience including academic concerns, student well-being and student engagement.

### Pandemic and Academic Concerns

The impact of the abrupt transition from in-person to remote course delivery has attracted much interest. Researchers are working to understand the implications for academic achievement and on students' perceptions of the academic experience. Related to student well-being, several studies have reported increases in school related anxiety (Hicks et al. 2021). Frequently students report increased anxiety and depression as having a negative impact on academic performance (Healthy Minds Network 2020; Son et al. 2020). Motivation is also an important part of academic achievement, particularly in an online or hybrid learning environment. In the wake of the pandemic, many studies report low levels of academic motivation (Means et al. (2020); Hicks et al. 2021;

Wu & Teets 2021). Related to motivation, students are also reporting lower ability to focus on academics (Hicks et al. 2021). Not surprisingly, 70% of students in one survey reported falling behind in their studies as the result of the pandemic (Instructure 2020).

The pandemic is also having a negative impact on students' perceptions of their academic experience. The transition to online delivery has resulted in lower levels of student satisfaction with their institution (Means et al. 2020). Many students also report a negative impact on their perceived career readiness (Instructure 2020). It is important to note that the focus of much of the research presented on academic concerns was the initial transition to remote delivery in the spring of 2020. Less is known about the impact of return to campus efforts in the fall of 2020.

**Pandemic and Student Well-Being**

The impact of the pandemic on undergraduate student well-being is an area of great interest. Unfortunately, early reports indicate a negative impact on many indicators of well-being. A joint study performed by the Healthy Minds Network and the American College Health Association (2020) reports increased stress related to financial concerns, an increase in the prevalence of depression, and lower levels of psychological well-being. Similarly, Son et al. (2020) reported deterioration in mental health for college students resulting from many factors including health concerns for themselves and family, social distancing requirements, disruptions to sleeping patterns, and concerns over academic performance. Loneliness has been identified as a major mental health concern affecting many people in the wake of the pandemic (Kilgore et al. 2020). This is especially concerning for college age students who already reported the highest levels of loneliness and isolation of all age groups in the U.S. (Cigna 2018). While the pandemic has had a negative impact on many aspects of student well-being, some positives have also been noted including less illicit substance use, less binge drinking, and higher levels of perceived resiliency (Healthy Minds Network 2020).

**Pandemic and Student Engagement**

Closely related to the present study, some researchers have begun to investigate the impact of the pandemic on student engagement. In one study, 75% of U.S. respondents reported a negative impact on student engagement (Instructure 2020). Similar findings were reported by Daniels et al. (2021). When studying the transition of a general chemistry course to online following the pandemic, Wu & Teets (2021) report that while all students reported lower engagement, underrepresented people of color experienced the most significant drop. It is important to note that all three studies that investigated student engagement were post-test measures only. Students were asked following the pandemic their perceptions on the impact of the pandemic on student engagement. The current study differs as it uses a quantitative, pre-test/post-test design to investigate changes in psychological/emotional student engagement.

**Student Engagement**

Student engagement has been attributed to many benefits including increased academic performance, persistence, and satisfaction (Trowler & Trowler 2021). Recognizing its value, many researchers have sought to understand and define the multi-dimensional construct (Finn 1989; Fredericks et al. 2004, Lamborn et al. 1992). Expanding on previous work, Appleton et al. (2006) proposed that student engagement is a multi-dimensional construct that includes four

sub-types including academic, behavioral, cognitive, and psychological engagement. Indicators of academic engagement include time spent on coursework and homework completion. Behavioral engagement is evident in regular attendance, classroom participation, and extra-curricular participation. Cognitive engagement is less observable and more internal to the individual. It is present when students value the learning experience, view the curriculum as relevant, and exert effort in order to comprehend difficult concepts. Psychological engagement includes a sense of belonging and relationships with teachers and peers. Recognizing their congruence, previous researchers have equated psychological/emotional engagement to SOC, and employed measures of SOC as indicators of psychological engagement (Townley et al. 2013).

**Sense of Community**

While it is not a comprehensive measure of student engagement, the authors had the opportunity to investigate changes in SOC, a proxy for psychological engagement, resulting from the pandemic. McMillan and Chavis (1986) are recognized for developing the widely accepted definition and theory of SOC which was originally applied in an urban neighborhood setting. They defined SOC as "a feeling that members have a belonging, a feeling that members matter to one another and the group, and a shared faith that members' needs will be met through their commitment to be together" (p.9). They propose that the construct of SOC consists of four distinct elements: membership, influence, integration and fulfillment of needs, and shared emotional connection. The concept of SOC and its four elements have been applied by previous researchers in an educational setting (Townley et al. 2013; Vasquez 2018).

The first element of SOC, membership, is described as "the feeling of belonging or of sharing a sense of personal relatedness" (McMillan & Chavis 1986, p.9). Having a sense of belonging is an indicator of psychological student engagement. Membership requires reciprocity in that one must seek membership and invest themselves in a community and in return the community must accept the individual into their ranks. Prior to the pandemic adults between the ages of 18 and 22 reported the highest levels of loneliness and isolation of all age groups in the United States (Cigna 2018). Mandated lockdowns, campus closures, self-directed learning, and the cancellation of in person classes appears to have augmented these problems (Healthy Minds Network 2020; Rippé et al. 2021). It light of the recent pandemic is important to investigate the already fragile element of membership for students in undergraduate construction management programs. Perhaps more than ever, it is feasible for individuals to attend classes online or in large socially distanced spaces and successfully complete a degree without ever feeling like thy have become part of a community.

The second element of SOC is influence. Influence is a "sense of mattering, of making a difference to a group and of the group mattering to its members" (McMillan & Chavis 1986, p.9). This element implies a degree of ownership, that one will have some control in what the group does. Often mentioned along with mental health concerns, perceptions of loss of control have been commonly reported in the wake of the pandemic. Feelings of loss of control appears to be a greater concern for younger students (age 18-23) than older students (age 24 and greater) (Sirrine et al. 2021). In a recent study, Rippé et al. (2021) proposed pedagogical strategies aimed at boosting perceived control for undergraduate students. In light of the pandemic and increased feelings of loss of control, it is important to investigate changes in perceptions of influence within the undergraduate construction management community.

The third element of SOC is integration and fulfillment of needs. It means that there is "a feeling that members' needs will be met by the resources received through their membership in the group" (McMillan & Chavis 1989, p.9). One of the elements that attracts students to be part of a community are the rewards or benefits of membership, commonly known as reinforcement in the field of behavioral psychology. Prior to the pandemic, informal learning communities, student organizations, and student competition teams were readily accessible by students and served to support "similar needs, priorities, and goals" (p.13). Institutional responses to the pandemic had a direct impact on students' ability to connect to these valuable resources. Consequently, it is important to investigate the changes in integration and fulfillment of needs resulting from the pandemic.

The fourth element of SOC is shared emotional connection. It is "the commitment and belief that members have shared and will share history, common places, time together, and similar experiences" (McMillan & Chavis 1986, p.9). Shared emotional connection is a bond that can be developed through multiple interactions where individuals feel the interactions are positive and meaningful. This element appears to be particularly susceptible to the challenges presented by the pandemic. Remote instruction, social distancing, reduced densities, and other institutional measures were implemented to allow colleges to reopen after the pandemic (Bradley et al. 2020). The express point of many of the strategies was to limit time shared in common places. In contrast, the shared significant experience of enduring the pandemic as a student could in theory strengthen perceptions of shared connection. Investigating changes in shared emotional connection should provide valuable insight into the impact of the pandemic on SOC and student psychological engagement.

## METHODOLOGY

This study measured SOC within two undergraduate construction management programs in the U.S. Midwest before the COVID-19 pandemic and following the return to campus in fall 2020. While the two programs were similar in many ways (size, location, public affiliation), their institution's implemented different strategies in the return to campus. By comparing the pre-pandemic and post-return to campus scores, the researchers were able to better understand the impact of the institutional response on student SOC. This study was guided by the following research questions:

RQ1: Is there a difference in student sense of community before the pandemic and following the return to campus at each school?

RQ2: Is there a difference in the four elements of SOC before the pandemic and following the return to campus at each school?

RQ3: Is there a difference in the reported SOC between the two schools before the pandemic and following the return to campus?

A descriptive survey research design was used for this study. The SCI-2 Instrument developed by Community Science (2021) was used to measure SOC. The previously validated instrument uses twenty-four questions with Likert scale responses to establish a cumulative measure for SOC that can be broken down into four elements of community. The Likert scale questions include four

options scored from 0 – 3 allowing for a maximum SOC score of 72. The instrument was used with the permission of Community Science and the study was granted IRB approval at the sponsoring institution.

In addition to the SCI-2 Instrument, the survey collected demographic data including age, gender, race/ethnicity, year in school, first generation status, and transfer student status of the study participants. The survey also included two optional open-format questions where respondents could comment on what they have observed contributing the most to SOC and in what ways SOC could be strengthened within the program.

Initial data collection began in February 2020 as part of an effort to collect SOC data from construction management programs across the United States. Surveys were completed by two schools prior to the COVID-19 pandemic that forced most institutions to transition to online delivery. The two schools were public institutions from the U.S. Midwest with a similar program size. No additional data was collected in 2020 following the pandemic shutdown. Data collection efforts for a nationwide study were resumed in the spring of 2021. The two schools that had participated in the spring of 2020 were invited to participate a second time and data was collected from the same courses, all of which had the same instructors as the previous spring. This allowed the researchers to compare SOC results before the COVID-19 shutdown and following the return to campus at both schools. Due to the delicate and potentially harmful nature of the data collected, the researchers chose not to report the names of the participating institutions. In lieu of their names, participating schools are referred to as School #1 and School #2.

Because the courses and associated instructors had not changed between 2020 and 2021, the researchers propose that any significant difference in SOC values is likely the result of each school's response to the pandemic and the measures implemented in the return to campus. A comparison of the institutional responses to the COVID-19 pandemic is shown in Table 1. Differences in the institutional responses between schools are shown in bold print.

From Table 1 we see that there were differences in the institutional response in the return to campus following the pandemic. The primary differences were related to in-person versus virtual participation in activities and the setting for instructional delivery (auditorium style vs. smaller classrooms). The researchers also sought to identify any other difference between spring 2020 and spring 2021 that could have influenced SOC. One variable that was identified was faculty turnover. At School #1 there was a change from 5 full time faculty to 2 full time faculty with 1 new adjunct instructor. At School #2 there was no change in the program faculty. The authors acknowledge the potential for faculty turnover to influence student SOC. Therefore, the potential influence of the faculty turnover will be investigated through a qualitative analysis of the two open format questions from the survey that address what contributes to SOC and what can be done to strengthen SOC.

Each school was allowed to choose the scope of their data collection efforts. The incentive to collect more data was a better understanding of SOC in their construction program, especially for underrepresented populations. Schools were encouraged to invite participation across the program, including freshmen through seniors. Table 2 provides an estimate of the responses/response rates for the schools for 2020 and 2021. The responses rates range between 31.4% and 43.8%, with an average of 35.3%.

**Table 1 Comparison of the Institutional Response to the COVID-19 Pandemic**

| School #1 Spring 2020 | School #2 Spring 2020 |
|---|---|
| Transition to full online course delivery March 2020 | Transition to full online course delivery March 2020 |
| Student Organizations suspended | Student Organization suspended |
| No in-person graduation | No in-person graduation |
| | |
| School #1 Fall 2020 – Spring 2021 | School #2 Fall 2020 – Spring 2021 |
| CM classes return to in-person delivery | CM classes return to in-person delivery |
| Masks required, **social distancing in auditorium spaces, different than typical classrooms** | Masks required, **social distancing in the same classrooms typically used for courses** |
| **Student organizations resume virtually, not allowed to meet on campus** | **Student organization resume in person, allowed to meet on campus** |
| Participated in virtual ASC student construction competition, **half the number of teams as previous years** | Participated in virtual ASC student construction competition, **same number of teams as previous years** |
| **Virtual career fair event** | **In-person career fair event** |
| **No in-person graduation fall 2020** | **In-person graduation fall 2020, limited attendance** |
| In-person graduation spring 2021, limited attendance | In-person graduation spring 2021, limited attendance |

**Table 2 – Response Rate**

| School | School #1 2020 | School #1 2021 | School #2 2020 | School #2 2021 |
|---|---|---|---|---|
| Responses | 69 | 71 | 80 | 105 |
| Program Size | 220 | 220 | 240 | 240 |
| Response Rate | 31.4% | 32.3% | 33.3% | 43.8% |

Descriptive statistics were used to report the demographic and summary SOC data and to look for trends and possible relationships. Based on the ordinal nature of the Likert scale data from the survey instrument, the nonparametric Mann-Whitney U-test was used to test for differences between two groups. For this study the threshold for significance testing was set at .05. A thematic data analysis method was employed to investigate the two qualitative open format questions at School #1 (Glesne 2006). Student responses were organized and coded by major themes and then further segregated into subthemes when appropriate. Frequency tables were employed to reveal patterns in the data. The goal of the analysis process was to search for patterns within the data and that indicate the potential influence of faculty turnover on student SOC.

The authors acknowledge the following assumptions and limitations. Beyond the potential influence of faculty turnover at school #1 which will be addressed in the study, there may be other significant changes between 2020 and 2021 that the authors did not discover. Therefore, there is a

potential that other unknown factors could have influenced SOC between the two years at either school. Because the data was collected in the U.S. Midwest, attempts to make inferences beyond this geography should be limited. As with any survey research, it is assumed that the respondents answered questions honestly, with appropriate effort, and without exterior influence/interference.

## FINDINGS

Table 3 presents the summary demographic characteristics of the respondents shown by school. For the entire dataset, over 90% or respondents are males and nearly 85% or respondents are white. This is consistent with national demographic statistics that report 90.4% of construction management professionals are males and 79% are white (Data USA n.d.).

**Table 3 Demographic Summary**

| School | #1 – 2020 | #1 – 2021 | #2 – 2020 | #2 – 2021 | Total |
|---|---|---|---|---|---|
| All | 69 | 71 | 80 | 105 | 325 |
| Female | 2 | 5 | 8 | 12 | 27/8.3% |
| Male | 67 | 66 | 72 | 93 | 298/91.7% |
| Non-White | 21 | 13 | 5 | 11 | 50/15.4% |
| White | 48 | 58 | 75 | 94 | 275/84.6% |
| Freshman | 0 | 0 | 17 | 28 | 45/13.8% |
| Sophomore | 15 | 10 | 9 | 14 | 48/14.8% |
| Junior | 10 | 9 | 12 | 19 | 50/15.4% |
| Senior | 44 | 52 | 42 | 44 | 182/56.0% |

In response to the first research question, Table 4 presents the cumulative SOC scores by school and year along with the results of the Mann-Whitney test investigating a difference in SOC at each school between the spring of 2020 and the spring of 2021. At School #1 we see that the cumulative SOC score for all students dropped over five points and the difference is statistically significant. At School #2 the cumulative SOC increased 2.47 points and the difference is not statistically significant.

**Table 4 Difference in SOC at Each School Between 2020 and 2021**

| | 2020 | 2021 | Significance Test |
|---|---|---|---|
| School #1 | 40.12 | 35.09 | $U = 1917.00$, $Z = -2.22$, $p. < .05$ |
| School #2 | 42.77 | 45.24 | $U = 3580.50$, $Z = -1.72$, n.s. |

Based on the results it appears that the institutional response to the pandemic and plans to return to campus, or a combination of the pandemic response along with the faculty turnover had a negative impact on SOC at school #1. At School #2 there was no significant impact on SOC based on their response to the COVID-19 pandemic.

In response to the second research question the researchers tested for differences in the four sub-dimensions of SOC between 2020 and 2021 at each school. Table 5 presents the scores for each element by school and year along with the results of the Mann-Whitney test.

**Table 5 Difference in sub-dimensions of SOC between 2020 and 2021**

| School | Sub-Dimension | 2020 | 2021 | Significance Test |
|---|---|---|---|---|
| #1 | Membership | 9.96 | 8.10 | U = 1844.00, Z = -5.53, *p.* < .05 |
| #1 | Influence | 8.91 | 7.79 | U = 2025.00, Z = -1.78, n.s. |
| #1 | Integration / Fulfillment of Needs | 11.23 | 10.23 | U = 2053.50, Z = -1.66, n.s. |
| #1 | Shared Emotional Connection | 10.02 | 8.97 | U = 2083.50, Z = -1.53, n.s. |
| #2 | Membership | 9.89 | 9.81 | U = 4163.00, Z = -.10, n.s. |
| #2 | Influence | 10.16 | 10.90 | U = 3515.00, Z = -1.91, n.s. |
| #2 | Integration / Fulfillment of Needs | 12.00 | 12.95 | U = 3486.00, Z = -1.99, *p.* < .05 |
| #2 | Shared Emotional Connection | 10.71 | 11.59 | U = 3579.50, Z = -1.73, n.s. |

At School #1 the element of membership was significantly lower in 2021 than 2020. Differences in the remaining three sub-dimensions of SOC were not significant. At School #2 the element of reinforcement was significantly higher in 2021 than 2020. Differences in the remaining three sub-dimensions of SOC were not significant.

In response to the third research question, Table 6 presents the SOC scores by school and year along with the results of the Mann-Whitney test investigating a difference in SOC between schools before COVID-19 pandemic and after the return to campus.

**Table 6 Difference in SOC Between Schools in 2020 & 2021**

| | School #1 | School #2 | Significance Test |
|---|---|---|---|
| 2020 | 40.12 | 42.77 | U = 2407.00, Z = -1.35, n.s. |
| 2021 | 35.09 | 45.25 | U = 2045.50, Z = -5.08, *p.* < .05 |

In 2020 the difference in cumulative SOC between the two schools was 2.65 points (out of 72) and the difference was not significant. In 2021 the difference in cumulative SOC increased to 10.16 points and the difference was significant. These results are consistent with the findings from the first research question. Prior to the pandemic the two schools reported similar SOC scores. However, it appears that the institutional response to the pandemic, or a combination of the institutional response along with other factors had a negative impact on SOC at School #1. This change let to a significant difference in SOC between the two schools in 2021.

In addition to the quantitative tests of the research questions, the authors also performed a summary qualitative analysis of the two open response questions from School #1. Responses from the 2020 and 2021 school years were compared to look for external influences on SOC other than the institutions response to COVID-19. In particular, the authors were looking for comments related to the impact of faculty turnover on SOC. The two questions as they appeared in the survey along with a summary tabulation of responses follow.

Question #1: What have you observed that contributes most to creating a sense of community within your major?

### School #1 2020

**Table 7 School #1 Comparison for Question #1**

| Response: | 2020 | 2021 |
|---|---|---|
| Group projects/homework & collaboration in the classroom | 12 | 6 |
| Extra-curricular activities (career fair, club meetings, competitions, socials) | 12 | 10 |
| Sharing common interests and goals | 10 | 6 |
| **Good relationship with faculty** | **10** | **2** |
| Building friendships within the program/friendly people | 9 | 6 |
| Same classes together year after year | 8 | 3 |
| Small community/class size | 7 | 5 |
| **Electronic communication between students (group chats, LinkedIn)** | **0** | **7** |
| **Same faculty throughout your college career** | **1** | **0** |
| People are always talking to each other | 1 | 0 |

From Table 7 we see that the major themes identified by the respondents are generally similar in 2020 and 2021. Of the three themes that were unique to either 2020 or 2021, the importance of electronic communications in creating community was a notable trend that emerged following the pandemic. It is worth pointing out that one respondent in 2020 mentioned the importance of the same faculty throughout the college career and that comment was not repeated in the following year. Good relationships with the faculty were noted in both 2020 and 2021. However, the number of responses dropped from ten to two between 2020 and 2021.

The summary presented in Table 7 contributes to our understanding of the change in SOC between 2020 and 2021 at School #1. While many common themes are present for both years, the institutional response to the pandemic appears to have placed an emphasis on electronic communication platforms to sustain a sense of community within the program. It also appears that the faculty turnover may have also had some influence on the reported SOC within the program.

Question #2: In what ways could the sense of community be strengthened for students in your major?

From Table 8 we see that the dominant themes are generally similar in 2020 and 2021. When commenting on ways to strengthen SOC, there were three themes that emerged in 2021 that appear to be related to the pandemic. The end of COVID restrictions was specifically called out along with the need for more construction groups/clubs and the need for students to get to know each other. While minimal, the influence of faculty turnover may also be present with one comment each emerging in 2021 about the confidence in the professors and the need for faculty development.

As with the previous question, the responses to Question #2 provide additional perspective on the changes that occurred at School #1 between 2020 and 2021. While many of the same dominant themes are present in both years, three notable themes emerged in 2021 that can reasonably be attributed to the pandemic and the associated institutional response. However, the influence of faculty turnover may also be present as two new responses point to faculty concerns in 2021.

**Table 8 School #1 Comparison for Question #2**

| Response: | 2020 | 2021 |
|---|---|---|
| More extra-curricular professional & fun events/out of class | 21 | 15 |
| More group projects & collaboration in the classroom | 9 | 4 |
| More student involvement with construction clubs and events | 7 | 5 |
| Being more accepting/open minded/inclusive to all students | 3 | 2 |
| Events to mix grade levels, under and upper classmen | 2 | 0 |
| Encourage freshmen to collaborate/get to know each other | 1 | 1 |
| **More construction groups/clubs** | **0** | **4** |
| **Encourage students to talk/get to know each other** | **0** | **4** |
| **The end of COVID & associated restrictions** | **0** | **4** |
| Better extra-curricular events / more interesting to students | 1 | 0 |
| More democracy, allow students influence decisions | 1 | 0 |
| Better advertisement of club events | 1 | 0 |
| Better leadership/leaders | 1 | 0 |
| More events that are free | 1 | 0 |
| More hands-on work makes people closer | 1 | 0 |
| Faculty to stress student work ethic/academic integrity | 1 | 0 |
| New student leaders | 0 | 1 |
| More trust among students | 0 | 1 |
| Students to be involved with campus renovations | 0 | 1 |
| **More confidence in professors** | **0** | **1** |
| **Professors need to be updated on current construction technology and practices** | **0** | **1** |

## CONCLUSIONS AND RECOMMENDATIONS

The results presented in the previous section report changes in SOC, a proxy for psychological student engagement, at two Midwestern construction management programs between 2020 and 2021. While there are many external factors that could impact SOC, the most likely reason for significant changes during this time period would have been the response to the COVID-19 pandemic at each institution. Based on the significant findings, it is important to reflect on what the data tell us about the response to the pandemic and how to address similar challenges in the future.

Based on the findings the authors propose the following conclusions. First, the institutional response to a major event such as the recent COVID-19 pandemic can have a significant impact on psychological student engagement. Unfortunately, at School #1 the measures implemented to protect students, faculty and staff resulted in a significant drop in SOC. However, while School #2 initially implemented a similar response to the pandemic, differences in their strategy to return to campus over the following two semesters appear to have mitigated the negative impact of the pandemic on SOC. Therefore, while threats like the recent pandemic do present challenges to

higher education, their impacts can be mitigated through carefully designed responses. The authors acknowledge that there was faculty turnover at School #1 between the 2020 and 2021 school years which may have had an impact on SOC. The qualitative analysis of the two-open response questions support that the faculty changes may have had an influence on SOC. However, the comments reflect a more substantial impact associated with the institutional response to COVID-19.

A further analysis of the four elements of SOC at School #1 indicate that their institutional response to the pandemic had a negative impact on membership which is described as "the feeling of belonging or of sharing a sense of personal relatedness" (McMillan & Chavis 1986, p.9). This leads to the second conclusion which is that connecting virtually is not the same as connecting in person. In the fall of 2020, both schools had similar opportunities in regards to returning to the classroom, participating in student organizations and competitions, and taking part in career fair events. The primary difference was that School #2 transitioned away from virtual to in-person events sooner. While virtual tools allowed many schools and businesses to navigate the worst of the pandemic, they did not produce the same sense of belonging and personal relatedness that is achieved through in-person experiences. The rapid return to in-person events may have also contributed to the significantly higher scores for integration and fulfillment of needs at School #2. One could speculate that allowing students to connect in-person with student organizations, pushing for participation with student competitions, and the perceived rewards associated with in-person recruiting events may have been viewed as rewards/reinforcement that were unique to their program and institution.

The results of this study provide a better understanding of how an institutions' response to a crisis can impact SOC, one element of student engagement. Based on the findings, the authors recommend that when preparing strategies to address similar challenges in the future, schools should carefully consider the effect of their response and endeavor to manage risk while supporting students' need for community. While it may not always be possible, schools should prioritize in-person classroom and extracurricular experiences over virtual opportunities. While connecting virtually was important in the early stages of the COVID-19 pandemic, it was not as effective as in person experiences in creating a sense of belonging. The emphasis for this paper was the institutional response to the pandemic. However, it is important to note the role that faculty play in encouraging engagement and building community. When faced with similar challenges in the future construction faculty should seek any opportunity to reinforce student engagement and maintain SOC within their programs.

The pandemic has created vast opportunities for future research. This study investigated the impact of the institutional response to the pandemic in higher education. Future studies should consider the impact of the transition to socially distanced virtual interaction on the workplace, places of worship, families, etc. While this study focused on SOC, future studies should investigate the impact of the institutional response to the pandemic on student organizations, communication patterns, academic achievement, recruiting, retention and other elements of the educational experience.

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# Using Flight Simulation as a Convenient Method for UAS Flight Assessment for Contractors

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## ABSTRACT

*Operating an unmanned aircraft system (UAS) for commercial purposes in the United States requires the pilot to pass the Federal Aviation Administration's (FAA's) knowledge exam to earn their UAS license. The exam does not include a practical component where flight proficiency is assessed. This represents a source of risk for contractors if flight proficiency is not evaluated in another way. The National Institute of Standards and Technology is a federal agency and has developed the Basic Maneuvering Test (BMT). It is the only nationally recognized UAS flight proficiency exam. While not required, the construction industry can benefit by using this exam to evaluate their pilots. However, there are costs to build the test lane and has logistical challenges to administer. This study shows that a newly developed BMT computer simulation is a convenient alternative to the traditional in-person exam. Twenty-four Part 107 pilots were given the BMT in-person and with the simulator. In addition, the physical location of the UAS from the target was evaluated against the exam parameters. The pilots' exam scores and times were statistically the same when using both testing methods. The study also suggests the construction industry can reduce risk within their UAS program by using the simulator for training and evaluation.*

**Keywords:** UAS, UAV, NIST, drone, construction, simulator, assessment, proficiency

## Author Bios

**Colin Dees** is a current Ph.D. student at Clemson University's Nieri Family Department of Construction Science and Management. His research aims to identify alternative ways of testing sUAS pilots and establishing flight proficiency standards. He is a licensed remote pilot with the United States Federal Aviation Administration (FAA) and is also a certified National Institute of Standards and Testing (NIST) test methods proctor issued by the Airborne Public Safety Association (APSA)

**Joseph Burgett** is an associate professor at Clemson University's Nieri Family Department of Construction Science and Management. His area of research is unmanned aerial systems with specific applications to the built environment. He is also the President and Director of the South Carolina Interagency Drone Users Consortium (SCiDUC).

# INTRODUCTION

Unmanned aerial vehicles (UAVs), commonly referred to as drones, are being used across the construction industry. UAV refers to the drone or the aircraft itself. An unmanned aircraft system (UAS) is a holistic system that includes the drone and the controller, ground control station, and anything else involved in keeping the drone in flight. Over the past five years, the number of industries using UASs has grown significantly. Some of the applications include construction safety monitoring (Gheisari et al. 2014), disaster management (Adams et al. 2014), roof inspections (Rakha & Gorodetsky 2018), land surveying (Agüera-Vega et al. 2017), stockpile calculations (Hugenholtz et al. 2015), landslide monitoring (Lucieer et al. 2013), bridge inspection (Dorafshan & Maguire 2018), and construction progress monitoring (Lin et al. 2015). As of November 2021, there were 865,607 commercial, recreational, and other drones registered in the United States (Federal Aviation Administration [FAA] 2021).

Pilots must receive a "remote pilot certificate" through the FAA to operate a drone commercially in the United States. Pilots with current manned aircraft licenses must take a self-paced FAA online course to earn their certificate. Because the majority of drone operators do not have a current license, they are required to take a knowledge test as a prerequisite to earning their certification. The knowledge test is a computerized test given at a third-party testing site. Currently, demonstrating flight proficiency is not a requirement for commercial drone operation. Drone operators can be fully licensed without having ever operated a UAS before. This represents a potential source of significant risk if contractors don't address it. Addressing this risk is the focus of this paper.

## The NIST Basic Maneuvering Test

The Basic Maneuvering Test (BMT) developed by the National Institute of Science and Technology (NIST) is the only nationally recognized flight proficiency exam for multirotor UASs. The BMT requires pilots to position their drone a set distance, which is denoted by the variable "S," away from a series of targets. Targets are located in the bottom of two-gallon buckets affixed on stands that are angled at either 45 degrees with the ground or straight up. Because the targets are at the bottom of the bucket, the pilot must position the drone directly in front of the bucket to see the entire target, as shown in Figure 1. If the drone is out of alignment, the bucket walls will obstruct the view of the target. Proctors administering the exam read aloud the instructions to the pilots, directing them where to be positioned and what target they need to take a picture of. The positional instructions are provided in multiples of "S" distance vertically and horizontally away from the bucket stands.

As with most practical exams conducted under real-world conditions, limitations are impacting the administration of the exam and using it as a standardized test. A significant consideration with any UAS practical exam is the weather. Varying wind speeds from test to test reduces the standardization of the exam. An exam with varying difficulty can create significant issues for an organization wishing to credential its pilots. Varying sunlight, the pilot's exposure to the elements during the exam, periodic GPS satellite loss, and differences in the aircraft detract from the standardization of any in-person UAS practical exam. A unique limitation to the BMT is the necessity to position the drone at "S" distance horizontally and vertically away from the targets. The BMT requires the proctor to visually observe this distance and deduct points for being outside of set tolerances. Measuring the "S" distance while the drone is in flight is very difficult to do with

precision and again adds variance to standardization.

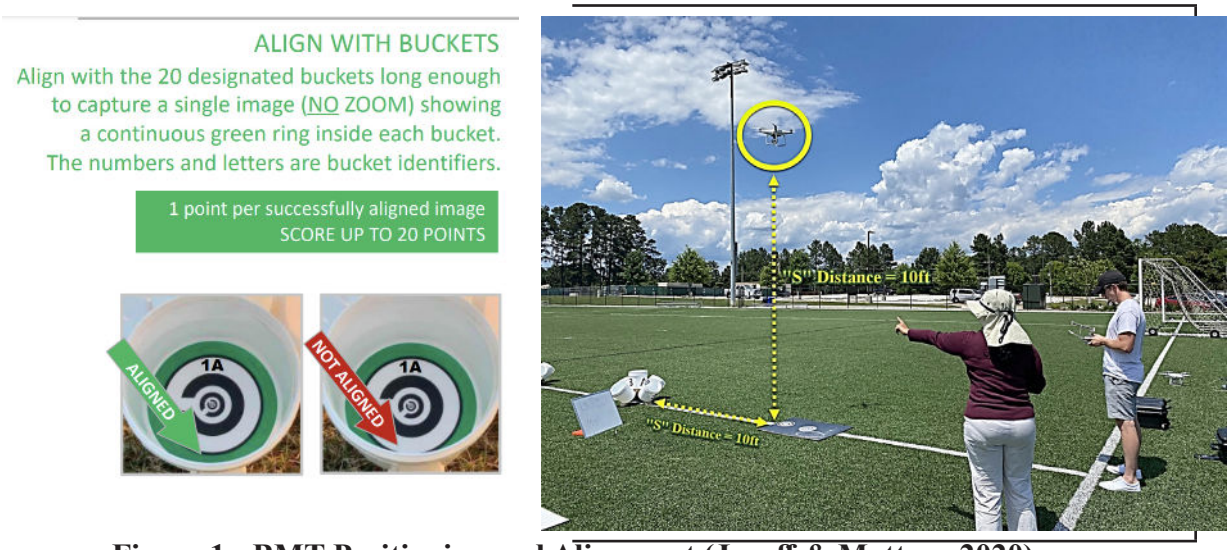


**Figure 1: BMT Positioning and Alignment (Jacoff & Mattson 2020)**

### Objective

As there is currently no requirement to demonstrate a minimum piloting competence at the state or federal level, many contractors elect to test their pilots in-house. However, given the standardization and logistical challenges with any in-person practical exam, this study suggests a preferred alternative to certify pilots via a computer simulator. A simulated flight exam can standardize all variables, is less costly, and significantly more convenient to administer. The focus of this study is to verify that a simulator recently developed by the research team and available to contractors can evaluate pilots' flight proficiency as well as a traditional in-person exam. The research team administered the in-person BMT with 24 FAA Part 107 pilots to accomplish this. After completing the conventional BMT, the pilots immediately took the same exam with the simulator. Their scores were evaluated, and a statistical comparison was made. The study also assessed the unique BMT limitation of having the proctor enforce the "S" distance requirement. This limitation is difficult to measure in the field but can be easily accounted for in the simulator.

## BACKGROUND

The need for proficiency tests in construction has become increasingly necessary (Frazier 2020). Despite the significant increase in drone registration and applications, the average pilot remains relatively inexperienced. Figure 2 shows the years of experience of the participants in operating a UAS for this study's sample and for a study by Nguyen et al. (2020). The figure shows that over 75% of the participants in this research have three years or less experience. Similarly, the chart on the right shows that 78% of the public sector using drones has three years or less of experience.

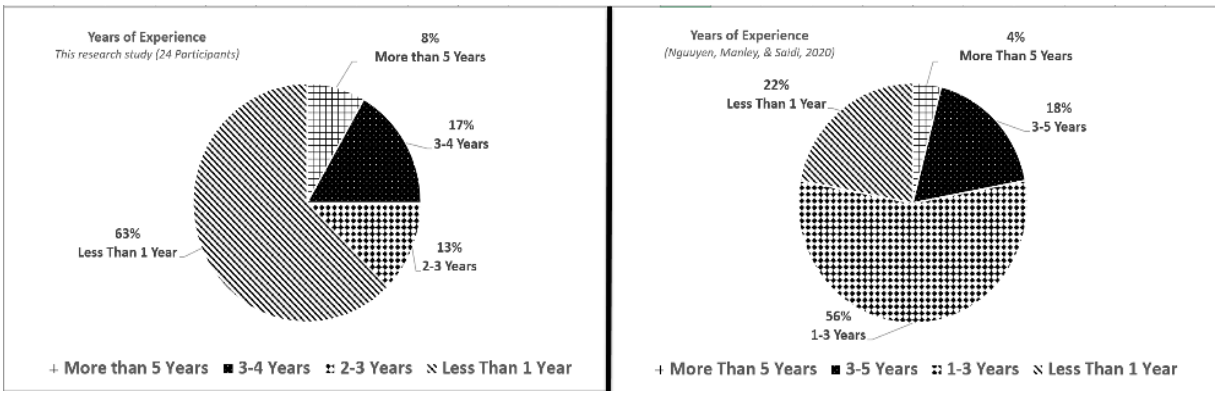


**Figure 2: Years of Experience Operating a Small UAS (Nguyen, Manley, & Saidi 2020)**

## FAA Part 107 Knowledge Test

In 2016, the FAA introduced the U.S. Code of Federal Regulations 14 Part 107 – Small Unmanned Aircraft Systems (Part 107) to govern UAS operations in the national airspace. The FAA rules cover a broad spectrum of commercial and government uses for drones weighing less than 55 pounds (FAA 2021). The remote pilot certificate, commonly referred to as a "drone license," gives pilots the authority to use a drone for commercial purposes. The Part 107 certification requires pilots to pass a written exam that covers a wide range of subject matter, including airspace, aeronautical charts, meteorology, aeronautical decision making, and the specifics of the Part 107 regulations. The exam contains 60 multiple choice questions given over two hours. Examinees are given a booklet that contains sectional charts, loading tables, weather forecasts, airport data, and a host of other material used during the exam. The exam is administered at a third-party testing site that often administers other exams, such as the Scholastic Aptitude Test, American College Testing, and Graduate Record Examination. The FAA Part 107 certification does not include a practical examination, and as such, there is no national standard for remote pilot flight proficiency (Frazier 2020).

## National Institute of Standards and Technology

NIST was founded in 1901 as a federal laboratory and is part of the U.S. Department of Commerce (NIST 2021). NIST's mission is to promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve our quality of life (NIST 2021). Another objective of NIST lies in developing the measures and means necessary to quantitatively evaluate robotic system capabilities and remote pilot proficiency (NIST 2021).

## Basic Maneuvering Test

The NIST BMT has been standardized through the American Society for Testing and Materials (ASTM) International Standards Committee, Response Robots (ASTM E54.09; Frazier 2020). The exam was created to assess a pilot's skills and proficiency. While the BMT is recognized nationally, NIST does not provide flight proficiency certification. There are organizations, such as the Airborne Public Safety Association (APSA 2021), that use exams similar to the BMT for flight

certification, but these are private certifications not currently endorsed by any federal agency.

The BMT test lane consists of a flight line, launch pad, and a series of four bucket stands. Each bucket stand has five, two-gallon buckets with a circular target at the bottom. Four buckets are angled at 45 degrees from the ground, and the fifth is pointed straight up. The flight line, launch pad, and first three-bucket stands are located "S" distance apart. The fourth bucket stand is located "4S" from the third bucket stand. The unit "S" can be any distance the proctor chooses but is often 10 feet. The proctor will read aloud the instructions that direct the pilot to position the UAS with relation to "S" distance horizontally and vertically from a specific target. Once in place, pilots will take a picture of the target. The target is round, covers the bottom of the two-gallon bucket, and is surrounded by a green ring around the outside perimeter. To be awarded points, the pilot must image a portion of the green ring around the entire perimeter of the target. See Figure 1 for an illustration.

The BMT is composed of five sets of maneuvers (see Figure 3). Maneuver 1: Position requires the pilot to capture images while navigating forward and backward down the centerline of the test lane. This is the only maneuver that requires the pilot to climb to "2S" (vertically). Most of the maneuvers are to be conducted at "S" altitude. Maneuver 2: Traverse has the pilot rotate in an oval pattern around bucket stands 1, 2, and 3. The pilot is instructed to be "S" distance above and away from the targets. The pilot completes this exercise twice in alternating clockwise/counterclockwise patterns. Maneuver 3: Orbit requires the pilot to orbit around bucket stand 3 four times in an alternating clockwise/counterclockwise pattern at "S" distance from the ground. Like maneuver 2, the pilot is instructed to be "S" distance horizontally and vertically from the targets. Maneuver 4: Spiral requires the pilot to rotate around all four bucket stands in order, alternating direction from clockwise to counterclockwise as the pilot moves from one bucket stand to the next. This maneuver is unique because the pilot is free to conduct the maneuver at any distance and is not bound to an "S" distance. Maneuver 5: Recon requires the pilot to fly straight and level from the launch pad to the fourth bucket stand at "S" distance above the ground. The straight flight from the launch pad to the bucket stand is repeated five times. Each maneuver requires the drone to be aligned with 20 designated two-gallon buckets long enough to capture a single image showing a continuous green ring on the target. One point is awarded for each successfully aligned image, scoring up to 20 points per maneuver, for a total of 100 points per test. Figure 3 shows the maneuvering for each of the five tests.

The BMT tests for small UASs are used to quantitatively evaluate pilot proficiency. They are standardized through the ASTM International Standards Committee on Homeland Security Applications, Response Robots (Mikolajewski 2022). They are also referenced as job performance requirements in the National Fire Protection Association Standard for Small Unmanned Aircraft Systems Used for Public Safety Operations (Jacoff 2021).

"Emergency response organizations can quantitatively establish reliability and confidence during training before drones and remote pilots are deployed in real-life situations," said Kamel Saidi, a NIST mechanical engineer in the Intelligent Systems Division (ISD; NIST 2021). It is estimated that over 1,700 U.S. public safety agencies have acquired small UASs (Frazier 2020). The relatively low cost of small UASs, combined with the simple process required to obtain an FAA Remote Pilot Certificate, has influenced law enforcement, fire, and search-and-rescue agencies to adopt the technology (Frazier 2020).

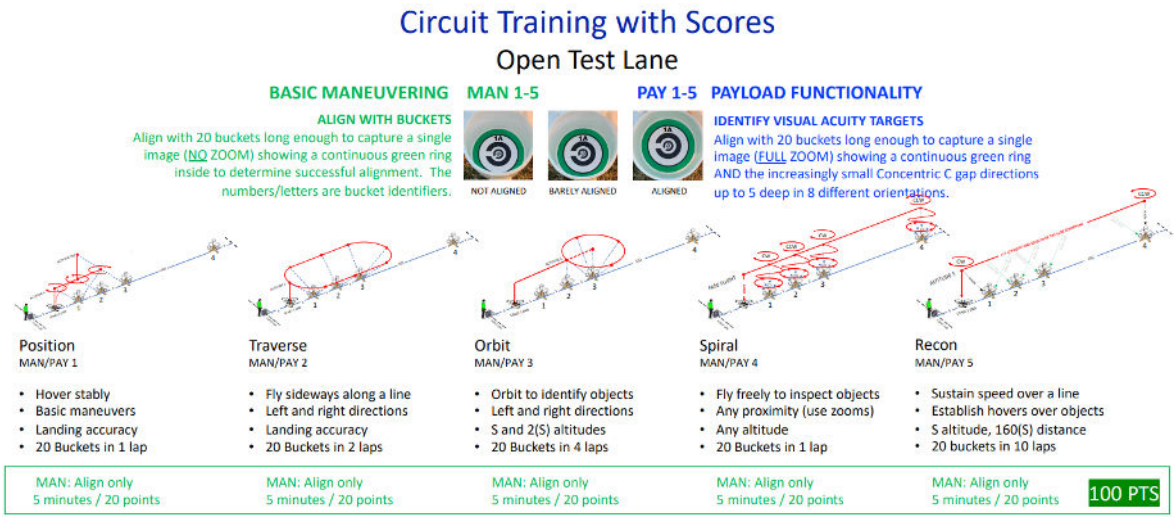


**Figure 3: NIST Basic Maneuvering Circuit Training with Scores (NIST 2021b.)**

## Limitations With the BMT

There are inherent challenges in using the NIST BMT for training pilots. First are the uncontrollable conditions of weather such as wind, sunlight, extreme hot or cold temperatures, and precipitation. It is difficult to maintain consistent environmental conditions to score the participants taking the exam consistently. Addressing these limitations is critical because the BMT test is being used for certification.

### *"S" Distance Limitation*

At the beginning of the test, the "S" distance from the target is established by the proctor. This distance is usually set in increments of 10 feet but can be any distance the proctor chooses. Enforcing the "S" distance requirement with the naked eye is difficult. Extreme discrepancies can be seen, but precise tolerances are nearly impossible. Pilots are instructed to fly a specified "S" distance above and away from the target, as shown in Figure 4; however, they are scored only on being able to see the unbroken green ring of the target (see Figure 5). We will study the impact of this challenge of enforcing the "S" distance and show the difference in scoring if a tolerance is imposed.

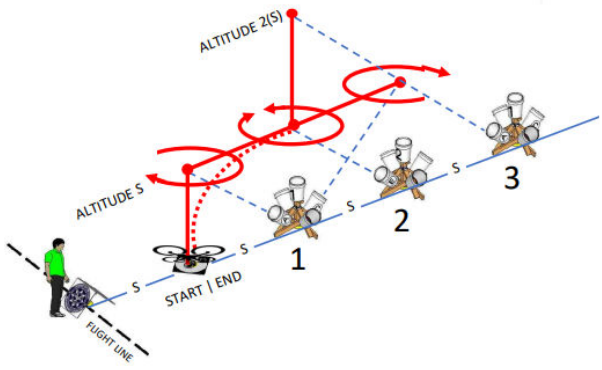


**Figure 4: Pilots Are Required to Fly Within a Specified "S" Distance from the Target (NIST 2020.)**

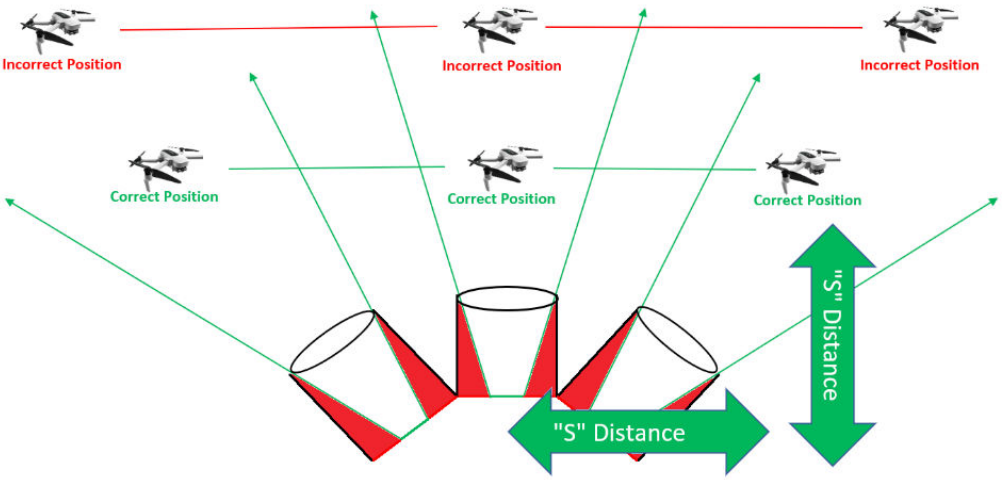


**Figure 5: "S" Distance Limitation Illustration**

## METHODOLOGY

The research institution created a survey that asked drone pilots about their experience level, UAS flight time, and comfort level with flying missions at varying difficulty levels. The survey was sent by email to 190 members of a local UAS nonprofit organization supporting local public agencies. A total of 24 participants completed the survey and participated in an experiment at the research team's university campus. The investigation had two parts: First, pilots took the BMT traditionally with in-person live proctoring, and second, pilots took the same BMT test but on a newly developed simulator.

### Traditional In-Person BMT

Three open test lanes were erected at an intermural soccer field using 10 feet as the "S" distance. The area was level, and the experiment took place on a warm, sunny day with a gentle breeze. Each lane was assigned a proctor to give the flight instructions and to record the participants' time. A dedicated pilot was assigned to each lane to record the exam with a secondary drone from an altitude of 250 feet. The research team provided either a model DJI Mavic 2 Pro drone or a DJI Phantom 4 Pro V2 drone to complete the test. These drones have similar flight characteristics. Differences in their flight performance were considered negligible for this experiment. Participants used the same drone model when they had completed the BMT on the simulator.

A time limit is often imposed with the BMT. NIST does not formally recommend a specific time limit, but common practice is to complete each maneuver in five minutes. The research team elected not to impose a time limit on the test takers. The participants were free to take as much time as they needed to complete the exam. This was done because the researchers wanted to test whether the pilots' performance on the BMT was the same for the in-person as for the simulator exam. By not imposing a limit, the time to complete had a greater range and allowed for a more robust statistical similarity comparison.

An attempt to calculate and measure the "S" distance using GPS coordinates was completed.

During the calculation, it was quickly identified that the coordinates from the drone images were not accurate. Even though the researchers were confident in the locations of the bucket stands, they were not comfortable with the distance calculations because of the inaccuracy of the GPS metadata in the drone's imagery.

Once the BMT test was completed, several examinations were conducted to measure the "S" distance and score the objectives by viewing video from a drone that was positioned 250 feet above the experiment. A grid was laid over the video, with each square or cell representing a one-foot square cube. This made it possible to view the drone during the video; measure the "S" distance requirement; and therefore, score the test as accurately as possible. If the distance were measured to be three feet out of tolerance from the one-foot required distance, a point was deducted from that objective (see Figure 6).

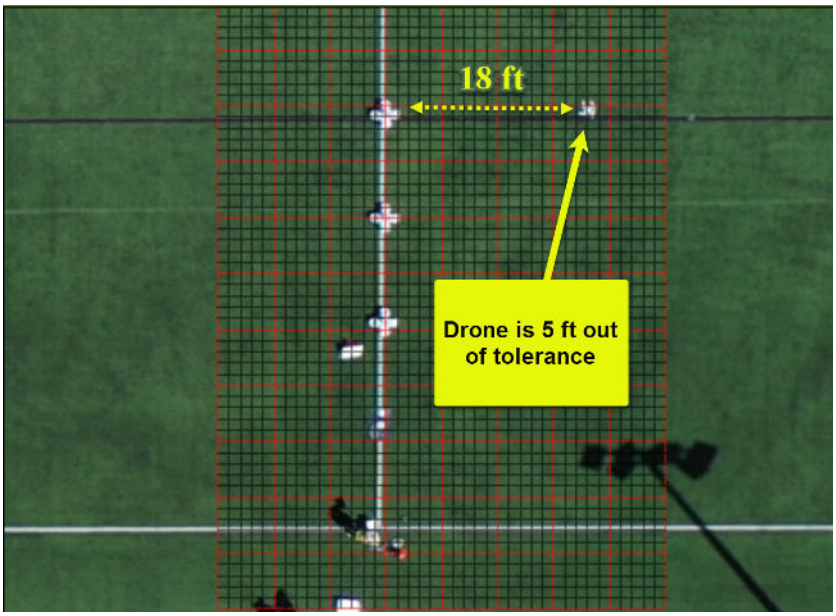


**Figure 6: Measuring the "S" Distance Using Video From an Overhead Drone**

### Simulator BMT

Once the participant had completed the traditional in-person BMT, they were instructed to proceed to the researcher's lab nearby to complete the test using a newly developed simulator. The simulator represented the test conditions very closely. Pilots were given an auditory click to complete the exam just as they were in the in-person test. The instructions were also provided with a text on the simulator screen. The script was the exact text provided on the NIST scoresheet used with traditional BMT proctoring. The controller had a standard UAS stick configuration that was the same shape, weight, and feel as the DJI Phantom 4 Pro V2's controller. Pilots captured images using a button on the controller pushed with the right hand. The camera was pitched up and down with a roll button on the left-hand side of the controller. Once an image was taken, an auditory "camera click" was heard, and the next test instruction was given. Varying weather conditions could be set for the test, but a sunny day with no wind was programmed for this experiment. These were the same conditions as were used in the in-person BMT. The research team set up laptops

with sufficient RAM and graphics cards to run the software smoothly. They also provided 70-inch monitors and headsets (see Figure 7). A lab assistant was available to help with logistics, but the simulator was completely self-proctored. The simulator scored the exam using a three-foot and an infinite tolerance of "S."

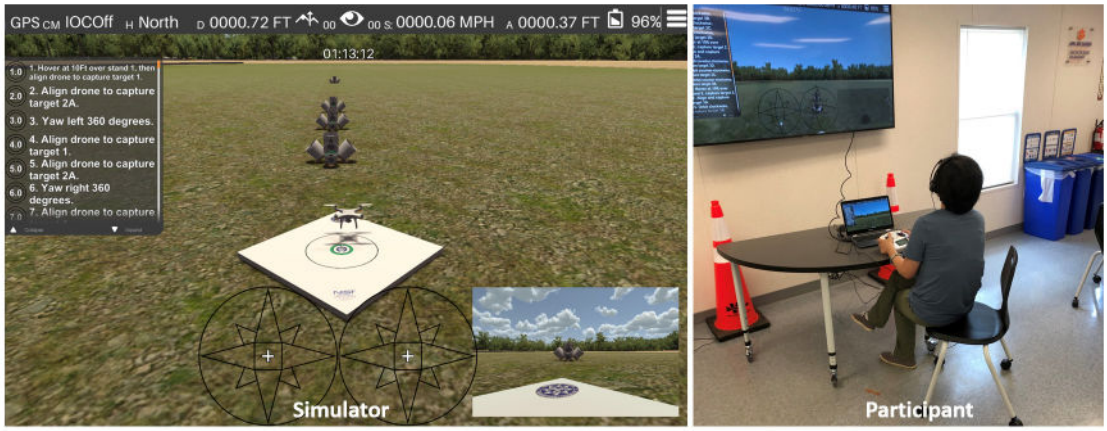


**Figure 7: Administering Simulator BMT**

## RESULTS

### Survey Results

The research survey asked each participant to answer 17 questions to determine how proficient they are with flying a multirotor UAS drone. Each Likert scale question ranged from 1–5 with 1 being not experienced and 5 being extremely experienced. Because there were 17 questions with a maximum ranking of 5 points per question, the highest number of points possible was 85 points. The average score of the 24 participants was 47 out of 85 points. The average score for each question was 2.7 out of 5. The 24 participants sampled were positioned between slightly experienced and moderately experienced. Overall, the sample consisted of relatively novice drone operators (see Figure 8) with slightly more than the average number of years of experience identified in the Nguyen et al. (2020) study (see Figure 2).

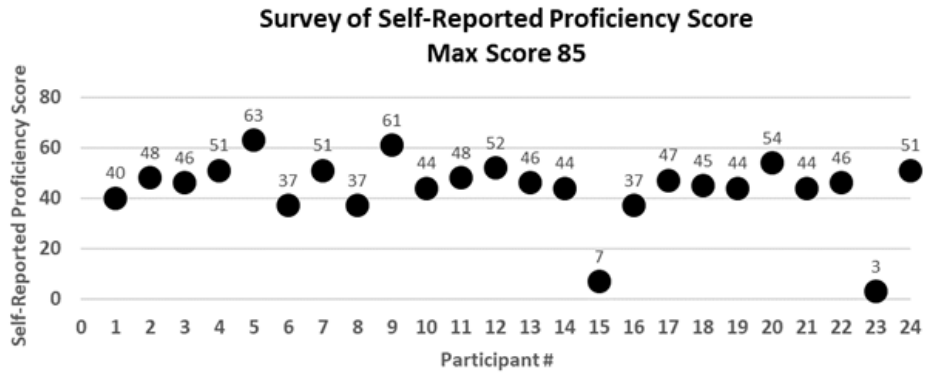


**Figure 8: Self-Reported Proficiency Score Results for All 24 Participants**

## Traditional In-Person BMT Results

A 10-foot "S" distance was selected for the experiment with a three-foot and infinite tolerance for scoring. When a three-foot tolerance was imposed, a point was awarded when an image was captured between 7 feet and 13 feet. Table 1 shows how out of position the 24 participants were by maneuver. Maneuver 2 had the largest average distance, and maneuver 5 had the smallest distance. This range is likely a result of the complexity of the maneuver. Maneuver 2 requires the pilot to yaw and pitch at the same time. Maneuver 4 did not have a required "S" distance, so it was not applicable for this comparison.

**Table 1:** ***How Out of Position the Pilots Were by Maneuver***

| Man # | Avg Delta | Min Delta | Max Delta | St Dev Delta |
|---|---|---|---|---|
| Man 1: Position | 1.1 | 0 | 15 | 1.5 |
| Man 2: Traverse | 1.5 | 0 | 30 | 2.2 |
| Man 3: Orbit | 1.4 | 0 | 14 | 1.6 |
| Man 4: Spiral | n/a | n/a | n/a | n/a |
| Man 5: Recon | 1.0 | 0 | 9 | 1.2 |

Table 2 shows the in-person results from each of the BMTs. The "Traditional Scoring" column is the average BMT score using traditional methods where tolerance of "S" is not enforced (infinite tolerance). There is a maximum of 20 points possible for each of the maneuvers. The "3' Tolerance Scoring (GPS method)" column is the average score of the BMT when a three-foot tolerance is enforced. If the drone captured an image outside of the 7 to 13-foot range, a point was not awarded, even if the green ring were visible. The "S" distance was determined using the surveyed location of the target and GPS metadata in the image. The "3' Tolerance Scoring (video method)" is the same, but the "S" distance was determined by reviewing the overhead video of the test.

There was significant variance between the two methods. After the data were collected, it was discovered that the GPS units within the drones were not accurate enough for a meaningful comparison. This was determined by calculating the drone's distance when it had landed and taking a picture of stand 1. Because the drone was physically located on the launch pad, it should have been very close to 10 feet because that is the true distance from the stand. In many cases, the measurement calculation showed it was only a few feet or over 16 feet. These were lessons learned for future studies, but the GPS method was not used for significant comparisons because of its inaccuracy. The "Comparison" column shows the difference in scoring between the traditional method and when a three-foot tolerance was enforced, as determined with the video method.

As shown in Table 2, the scores were on average 4.9% lower when the "S" distance was enforced compared to traditional scoring methods. The most significant impact was with maneuver 2. There was a 10.1% lower score when the "S" distance was measured and enforced. Again, the "S" distance for maneuver 4 was not calculated because this maneuver was a free flight where the "S" distance was not required.

**Table 2: In-Person BMT Scores**

| Maneuver | Traditional Scoring | 3' Tolerance Scoring (GPS method) | 3' Tolerance Scoring (Video method) | Comparison |
|---|---|---|---|---|
| Man 1: Position | 19.3 | 8.0 | 19.0 | -1.6% |
| Man 2: Travers | 18.8 | 10.0 | 16.9 | -10.1% |
| Man 3: Orbit | 18.5 | 11.1 | 17.3 | -6.5% |
| Man 4: Spiral | n/a | n/a | n/a | n/a |
| Man 5: Recon | 18.8 | 9.6 | 18.5 | -1.7% |
| **Average** | **18.8** | **9.8** | **17.9** | **-4.9%** |

### Simulator BMT Results

Immediately after completing the in-person BMT, the participant completed the same test on a simulator. Table 3 presents the scoring results of the simulator BMT with and without a three-foot tolerance. Maneuver 4 allows the participant to engage in a "free flight" where "S" distance is not required and noted with "n/a" similar to Table 2. There was a 2.1% difference in overall scores when a three-foot tolerance was enforced. This was slightly less than what was seen with the in-person exam. There was some uncertainty as to why there was less difference between the two exams. It is possible that being seated in a comfortable air-conditioned space improved the scores. Also, the screen used with the simulator was larger, making it easier to navigate the exam. It is also possible that the pilots were more familiar with the exercise because they took the simulator exam after they had completed the in-person exam. More study is needed to determine the causation, but scores were different when the "S" distance is enforced in both exam methods, which is significant with standardized testing.

**Table 3: Simulator BMT Scores**

| Maneuver | Traditional Scoring | 3' Tolerance Scoring | Comparison |
|---|---|---|---|
| Man 1: Position | 18.2 | 18.0 | -0.9% |
| Man 2: Traverse | 17.0 | 16.7 | -2.0% |
| Man 3: Orbit | 18.8 | 18.6 | -0.9% |
| Man 4: Spiral | n/a | n/a | n/a |
| Man 5: Recon | 18.3 | 17.4 | -4.6% |
| **Total** | **18.1** | **17.7** | **-2.1%** |

Figure 9 compares the in-person and simulator BMT exam scores and times. Graphically, the scores and times seem strongly correlated. However, a Student's *t*-test at 95% confidence was conducted to confirm this (see Table 4). When all the maneuvers were combined and tested in aggregate, the p-value for scores and times were .260 and .364, respectively. P-values are used to determine whether the variances in data sets are by chance or have a statistically significant difference. P-values greater than .05 are generally considered to mean that the two data sets are

statistically the same. The p-values for scores and times shown in Table 4 indicate that the data sets are equivalent. A similar *t*-test was conducted for each of the maneuvers individually. The times and scores for each maneuver were statistically the same except for maneuver 1. The p-value comparing time (not score) for maneuver 1 was .004. On average, participants took 2 minutes and 34 seconds longer to complete the in-person test than to complete the simulator. The researchers believe that the in-person maneuvering 1 test took longer because it was the very first flight experience of the day and the participants were overcoming the learning curve of understanding the logistics of the NIST test. The majority of the participants had never completed a NIST test before, so additional time was needed to explain which targets they needed to capture an image of.

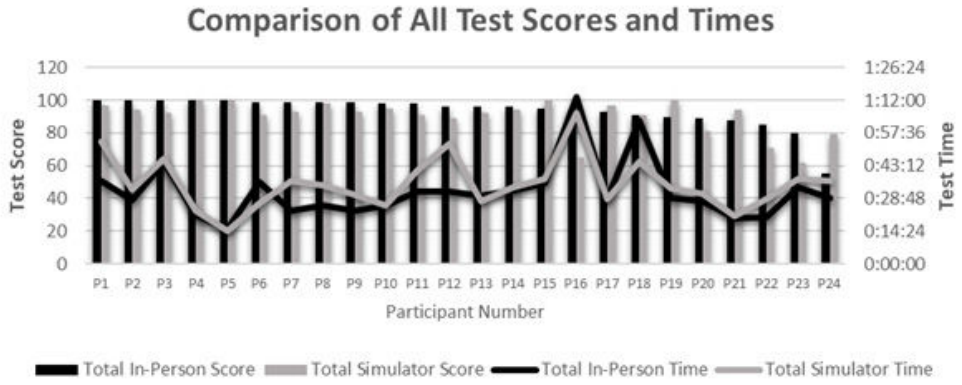


**Figure 9: Comparison of All Test Scores and Times**

**Table 4: Statistical Comparison and Similarity Between In-Person BMT and Simulator BMT**

| Man # | Avg. In-Person Score | Avg. Simulator Score | % Delta | p-value | Avg. In-Person Time | Avg. Simulator Time | p-value |
|---|---|---|---|---|---|---|---|
| Man 1: Position | 19.3 | 18.2 | -4.4% | 0.087 | 0:06:10 | 0:08:44 | 0.004 |
| Man 2: Traverse | 18.8 | 17.0 | -9.1% | 0.080 | 0:05:55 | 0:05:44 | 0.751 |
| Man 3: Orbit | 18.5 | 18.8 | 3.0% | 0.513 | 0:06:56 | 0:06:45 | 0.823 |
| Man 4: Spiral | 18.3 | 17.7 | -3.6% | 0.422 | 0:07:01 | 0:07:00 | 0.980 |
| Man 5: Recon | 18.8 | 18.3 | -3.7% | 0.272 | 0:05:57 | 0:07:02 | 0.181 |
| **Avg. of All Maneuvers** | **18.8** | **17.9** | **-3.6%** | **0.260** | **0:06:24** | **0:07:03** | **0.364** |

## DISCUSSION

For a contractor to use a drone on a jobsite, the operator must have earned their FAA Part 107 remote pilot certificate, which requires passing a knowledge exam. The exam requires the pilot to understand airspace, applicable regulations, and a wide range of other topics essential for operating in the national airspace. However, the knowledge test does not address in any way proficiency with

using a drone. The FAA can fully license a contractor's employee without having ever operated a UAS. This represents a significant source of risk for contractors using drones. As with all risks, the construction manager has several options for how it is addressed. First, they could absorb the risk. In the case of a drone program, this would be not to have any means of evaluating flight proficiency and trust the pilot has sufficient skills to complete the mission. This may be acceptable with a single pilot who has extensive experience and is able to self-evaluate the risk on behalf of the company. As the number of pilots increases, so does the risk of using this approach. Another option is to transfer the risk. This option would likely take the form of subcontracting drone services to a third-party vendor. With this option, the contractor gives up control of the drone program and is subject to the vendors' schedules and fees. This was a prevalent option early into small UAS use. However, as the equipment cost and regulations have decreased, more contractors want control of the data collection. Risk is also transferred by purchasing a UAS specific insurance policy and a good strategy with any drone program. Ideally, the best way to address risk is to mitigate it. Mitigating the risk associated with pilots with poor flight proficiency is the overarching goal of this field of research.

A common adage is that you can "only manage that which you can measure." For a contractor to manage the risk of UAS crashes, they must measure their pilots' flight proficiency. A contractor could develop their own test and evaluate their pilots. However, as the BMT is already developed by a federal agency and freely available to anyone, using it is likely the preferred option. Administering the in-person BMT does have logistical challenges. The cost to build a single lane is over 400 dollars and will require storage space when not in use. There is also a logistical challenge to securing a large field in uncontrolled airspace (or ATC approval) to conduct the test. The in-person exam also requires a proctor to administer and score the exam representing an investment in labor hours. These are not insurmountable barriers by any means, but they do require an investment of time and money.

This study suggests that a preferred alternative is administering the BMT with a simulator. In partnership with Little Arms Studios, the research team developed a simulation of the BMT. This study has shown in detail that the proficiency measured with the simulator is the same as when measured with a traditional in-person exam. A convenient way to manage the risk of poor flight proficiency is to develop a training and testing schedule with their pilots. This may require pilots to spend 30 minutes "behind the sticks" in the simulator every week. This paper has focused on the BMT simulation, but the software has numerous other scenarios, including a bridge inspection simulation developed by the research team. Construction managers could also require quarterly BMT testing via the simulator. This would document proficiency and be a useful tool to measure improvement over time. The most significant advantage of the simulation is that it requires almost no pre-planning or logistical pre-work. Unexpected rain days could be ideal times to practice flying. Pilots can simply load the program, practice for a while, and then close it down. The convenience would likely significantly increase the amount of training time. The research team does not endorse any specific program, but contractors interested in the software used for this study can go to zephyr-sim.com and learn more about the Zephyr simulator.

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