HEURISTICS AT WORK: THE PRESENCE AND IMPACT OF AVAILABILITY BIAS IN CONSTRUCTION WORKFORCE MANAGEMENT DECISION-MAKING

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HEURISTICS AT WORK: THE PRESENCE AND IMPACT OF AVAILABILITY BIAS IN CONSTRUCTION WORKFORCE MANAGEMENT DECISION-MAKING

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SUMMARY

Construction workforce management requires complex decision-making under constraints of time, resources, regulatory compliance and more importantly, cognitive resources. Despite widespread implementation of decision-support frameworks, cognitive biases such as heuristics may compromise managerial judgment. This study explores the current literature gap and implications of the availability heuristic in workforce-related decisions within the Architecture, Engineering, and Construction (AEC) industry. The availability heuristic is a cognitive bias wherein individuals estimate event probabilities based on memory accessibility rather than statistical accuracy.

A controlled survey-based experiment was conducted with 84 AEC professionals from across the United States. Participants were asked to allocate emergency workforce funds across five domains:

1. vocational training and education
2. employee health and welfare benefits;
3. occupational safety and health (OHS)
4. on-site project management
5. equity, diversity, and inclusion (EDI).

Each domain was accompanied by tailored familiarity assessments and randomized information stimuli to evaluate susceptibility to the heuristic.

Statistical analysis methods—including conditional probability and lift, T-tests, and Two-Way ANOVA—confirmed that higher familiarity strongly correlated with increased favoritism likelihood, substantiating the presence of availability heuristics. The heuristic's effects were found to be consistent across topic areas and professional demographics (role, experience, and location), indicating its ubiquitous influence in the industry. However, the effectiveness of an intuitive randomized exposure-based mitigation strategy was inconclusive and varied by domain, revealing limitations in simple cognitive debiasing approaches.

The study's findings highlight an overlooked vulnerability in AEC workforce management—cognitive biases may undermine rational decision-making despite professional expertise and structured frameworks. These insights underscore the necessity of incorporating behavioral economic principles into construction management processes to develop more resilient and bias-aware decision systems. This work serves as a foundational step in expanding behavioral research within infrastructure planning and project delivery contexts.

Keywords: Availability heuristic, cognitive bias, construction workforce management, AEC industry, decision-making, behavioral economics

CHAPTER 1
BACKGROUND LITERATURE REVIEW

1.1 Construction Workforce Management Challenges

Construction workforce management is an endeavor beyond traditional human resources, it requires the management to pursue maximum productivity with a diverse and geographically dispersed workforce while complying to complex regulations. Project stakeholders in the construction workforce constantly face a variety of critical challenges in their decision-making scenario [1]. Consequently, numerous systems and models have been developed to support optimal decision-making, including extensive applications of mathematical and psychological multi-criteria decision-making methods such as the Analytic Hierarchy Process (AHP), the Analytic Network Process (ANP), and others [2] [3]. However, a major behavioral economics perspective has been overlooked by industry and academia alike and opens up the AEC industry to cognitive biases in decision making. The core objective of this study is to investigate the presence, impact, and the causality of a particularly pervasive cognitive bias—Availability Heuristic, in the decision-makings of construction workforce management.

1.1.1 Onsite construction project management

As it is well-established, the AEC industry is a strenuous work environment that brings grave challenges in its workforce management [4]. Within it, a major challenge is its onsite project management. Project managers are required to coordinate, administer and oversee the workers' activities at the construction sites to maintain project productivity, safety compliances and many other key factors under specified time and budget constraints. In the literature, project managers struggle to properly engage workforce commitment and empowerments, which leads to labor productivity constraints [5]. They are also reported to show risk-chasing behaviors in on-site decision scenarios [6], especially in high-risk situations, and often leads to project budget and time overruns.

1.1.2 Construction worker training and retention

The entire AEC industry has been experiencing growing issue of labor shortage. According to a report by the Associated General Contractors of America (AGC) [7], 89% of construction firms faced challenges in hiring skilled workers in 2023 and an average 4.6% of construction positions were unfilled, which is the second highest in history trailing behind the year of 2022. The challenge in this issue is three-fold. First, the quantity of construction workforce is insufficient. According to the Associated Builders and Contractors [8], 501,000 workers in addition to normal hiring are needed in 2024 to meet the demand of the AEC industry. However, the younger generation is not particularly fond of joining the AEC industry. Although recent statistics show that the supply of construction workforce is growing slowly, it is far from filling the gap with the demand for construction. Secondly, there is also significant lacking in the quality of workers. During the pandemic, many projects were suspended and a significant proportion of skilled workers of age decided to retire, leaving a substantial absence of qualified and experienced labor in the job market, resulting in gaps of over 100 thousand and 150 thousand discrepancies between construction job openings and hires in the years of 2021 and 2022. Not only is it a a challenge to maintain construction quality currently, but also a challenge to cultivate a sustainable market of next generation skilled labor. This urges the industry to increase its investment in occupational training, which again is counterproductive for individual projects, adding difficulties managing workers' productivity on-site. Meanwhile, studies [9] have identified lacks of career pathway, investment in training and employment welfare as key workforce management factors contributing to high labor turnover rates. Having a clear career pathway that incorporates job satisfaction and work-life balance were discovered to be substantial motivators of general labor retention [10]. Furthermore, efficient training that enhances professional skills indirectly increases their prospect in the position alongside job satisfaction and promotability, therefore, decreases the likelihood of career turnovers [11].

1.1.3 Employment health & welfare benefits

Associated with worker retention, the health and welfare assurances are especially critical in the AEC industry due to the dangerous nature and high physical demand of construction work. Workers are prone to suffer from fatigue, injury and even fatality. A strong employment health and welfare program can help employees to respond more positively to their training and increase their willingness to stay in the industry [12]. Insufficient workers' welfare can substantially lower productivity as studies [13] have shown direct relations between the quality of site amenities and labor welfare with workforce productivity. Furthermore, requirements for workers' health and welfare have been emerging as a trending topic since the outbreak of Covid as researched by Nayana, N. and Chandana, S. in 2022 [14]. Workforce management must take the healthcare, insurance and additional compensations into account. However, while increased compensation is a straightforward solution and guarantees the welfare of workers, too much compensation puts the financial stability of the project and contractors in jeopardy. Therefore, determining the optimal extent of welfare compensation presents a challenging decision-making dilemma..

1.1.4 Occupational safety & health for construction work

The unique nature of the AEC industry comes with various hazards that contributes much higher fatality rate compared with other industries. Hence, the occupational health and safety (OHS) ofhave always been a top priority in construction workforce management. With critical life safety hanging in the balance, the compliance with the labor and safety regulations are restrictive and cause certain discomfort to the workers in terms of protective gear as well as work processes. Construction managers frequently encounter resistance to safety policies and face perceived trade-offs with productivity, making the balance between safety and productivity a complex and nuanced decision-making challenge. Furthermore, the fact that individual states have published numerous different regulations since the pandemic has added to the problem even more [15]. At the same time, the gradual but consistent aging of the AEC workforce and lack of young newcomers [16] compounded with the outflow of skilled labor during covid exacerbates the strain of proper OHS management decisions. In the literature, we were able to identify several systematic barriers of OHS systems and regulations. Gallagher et al. in 2001 [17] described that OHS must be integrated into the broader project management system to be effective whereas it is often considered a responsibility of specialty departments and dissected from the operational or strategic decision-making within organizations. Frick and Wren [18] pointed out that OHS operations tend to be overly complex, which can impede their own strategies and effectiveness. It was suggested that hazard prevention originated from the planning and design phase can have a significant impact in conveying OHS from decision-makers to the workers. However, while it is becoming widely accepted that OHS should be incorporated more upstream in the industry's developmnent cycle, it was shown by Lingard et al. [19] that the viability of OHS in earlier project phases is much more difficult due to the volatility and dynamic nature of construction designs.

1.1.5 Equity, diversity & inclusion

Lastly, construction workforce management requires improvement in equity, diversity and inclusion (EDI). Incorporating policies to better accept, support and include workforces for all human differences, including but not limited to race, ethnicity and gender is a relatively new challenge for the industry. The AEC workforce demographics is predominately white, male, heterosexual and able-bodied. While much work has been done to address the lack of equality and diversity in the industry for feminine workers [20], the industry had not been able to properly acknowledge how exactly the minority groups differ from majority groups in terms of workforce management. This might be particularly true for lesbian, gay, bisexual, transgender and intersex (LGBTI) groups. Efforts to understand differences within groups were recognize in literature to be insufficient in a number of key aspects [21]. For instance, while some women may enjoy the traditional, masculine work culture as most men, it is equally likely that a man can be uncomfortable with the assumed working culture. As such, not only are recognitions of different subordinate groups one-sided, but it would also be naïve to assume everyone in a specific ethnicity, age and sexuality groups would have the same experience as the presumed majority would do under the same policies. Therefore, it is crucial to further endorse a diverse and productive working culture. EDI can be beneficial to quality labor retention, which makes how to best attract and keep skilled labor through proper EDI policies a another critical issue for decision makers.

1.2 Potential of Cognitive Biases in Decision-making

The construction workforce management challenges outlined above involve complex decision-making under constraints of limited time and cognitive resources—conditions that are characteristic of heuristic-based mental shortcuts. While heuristics serve to streamline cognitive processing, they also render decision-makers susceptible to systematic cognitive biases. They subtly support decision-making in a faster, more concise manner at the expense of correctness, accuracy and optimality [22]. Despite our pursuit of rationality in construction management decision-making, mental shortcuts—such as heuristics—often emerge intuitively, particularly when individuals are compelled to make complex decisions under significant cognitive constraints.[23] [24]. Therefore, we cannot easily deny the possibility of these cognitive biases at play in construction workforce management decisions without meticulous examination. For example, risk-chasing behaviors in construction on-site management can stem from the availability heuristics and the gambler's fallacy because project managers tend to hear more about the successful projects and can falsely believe that events occurring in the future are influenced by previous instances of similar characteristics. In a similar manner, the Einstellung effect [25], wherein individuals unconsciously approach problems using strategies that were effective in the past, can impede the efficacy of occupational training. This cognitive bias may limit workers' capacity to assimilate better or safer solutions, as their prior experiences constrain their openness to alternative approaches.In the context of occupational health and safety (OHS), workforce managers may fall prey to the hot-hand fallacy [26] by overestimating the likelihood that an OHS system being successful in previous projects will perform equally well in characteristically different contexts. This cognitive bias can result in a failure to recognize the necessity for context-specific adaptations in workforce management strategies. Lastly, the negligence of different individual experiences in employee DEI even when the industry has recognized differences between groups can originate from cognitive dissonance where we avoid new beliefs without noticing. Hence, even with our strive for a well-informed and rational decision, there is a myriad of possibilities that cognitive biases could have been implicitly affecting the decision-makings within construction workforce management all along.

However, there is little literature addressing this particular problem other than the work done by YunPing L. in 2019 [27], where decision-making amongst AEC students were examined during Covid period. This study takes the scrutinization of cognitive biases in the AEC industry one step further in the direction of construction workforce management, and investigate the impact of Availability heuristics specifically. Availability heuristic [28] is a pervasive heuristic referring to a systematic illusory that the ease of recollecting relevant memories of an event can be mistakenly associated with higher probability estimations of its occurrence. When applying the heuristic, our cognitive process deviates from comprehensive statistics and facts toward evaluating probabilities of events based primarily on the perceived ease of recollecting relevant occurrences [29]. We selected this specific cognitive bias in a working professional's setting because failing or denying to recognize the exposure to it in the decision-making of construction workforce management can open AEC professionals to particularly substantial consequences. If exposed, the industry as a whole can be misjudging the availability of the workforce, develop a false assurance of labor skill levels and even systematically misjudge the policy directions for improving workforce management of the entire industry. The industry might fall victim to large-scale implicit biases and errors such as misconceptions of policies and improper industry resource allocations, creating a widespread impediment for construction workforce improvement around the nation without making a sound.

CHAPTER 2
RESEARCH OBJECTIVE

This paper focuses on investigating the presence and impact of availability heuristics in workforce management decision-making specifically in the context of the construction industry and infrastructure development. It allows the AEC industry to examine the current decision-making dynamics through an unprecedented perspective – behavioral economics, and potentially discover implicit fallacies. For instance, there can be improper recourse deployment where managers focus on copying unfit strategies from recent successful prominent projects, excessive investment where managers allocate resources heavily to one risk area due to recent accidents while neglecting other high-risk areas and even ineffective policies where long-term workforce policies are formed on short-term or individual disruptions and etc. We exclusively targeted experienced professionals in the AEC industry by conducting a controlled-variable survey experiment with industry experts. Subsequently, we performed statistical analysis to answer the following research questions. Through statistical inference and data mining, we provide insight into the bias's existence, contributing factors, its mitigation strategy and corresponding effectiveness, which will allow proactive avoidance and correction of such bias for decision makers in the AEC industry.

Hypothesis 1: ***Availability heuristics exist in the decision-making of AEC professionals***

Whilst industry experts are generally acknowledged to possess comprehensive knowledge of the field and a thorough cognitive process, it has been confirmed by previous studies [30] [31] that even experienced subject matter experts can be subjected to this heuristic. This research intends to find evidence supporting the presence of availability heuristic through the controlled experiment, where we investigate whether higher availability is associated with higher probabilities or favoritism during the decision-making process of AEC professionals.

Hypothesis 2: ***The impact of availability heuristics is consistent among different topics***

Upon investigating availability heuristic's presence, this paper also tested it among five different topics to corroborate whether the effect is consistent across different areas of expertise. Consistent results across the board can have significant implications that the heuristic is ubiquitous, unrelated to the inherent nature of the specific topic and should be actively aware by the AEC industry professionals regardless of their area of expertise. This paper attempts to confirm the hypothesis that the heuristic is consistent across topics by examining their statistical significance separately.

Hypothesis 3: ***Arbitrary exposure of additional information can be of assistance in reducing the effect of availability heuristics***

The bias of availability heuristic originates from a mental short cut relying on the availability of associated memories, so our experiment also incorporated a mitigation strategy that stochastically stimulated availabilities across different topics. As such, the availability of the participants would be effectively randomized. The mitigation is applicable by the AEC industry on a regular basis, and answers the question whether an individual could resist the availability heuristic by simply increasing his exposure to diverse information. Testing this hypothesis would have considerable practical value as it is a highly accessible defense mechanism to the heuristic.

Hypothesis 4: ***Susceptibility to the availability heuristic is related to the professional background of the personnel***

While counterintuitive to the natural perception that professionals are less inclined to biases, past literature has reported a tendency of heavy emphasis on specialization and insufficient exchange of thoughts between sections in construction companies [32]. This suggests that professionals are more immersed in their respective specializations and increases the availability of individual specific expertise, making them more susceptible to the availability heuristic. Therefore, it is essential to identify whether professional background in the AEC industry is a determining factor on the susceptibility of the heuristic.

CHAPTER 3
METHODOLOGY

3.1 Experimental Design

The experiment presented participants with a hypothetical decision-making scenario workflow, as depicted in Figure 3.1 (Experimental Design). They were given a detailed description of the scenario stating their identity as a reviewer to the organization (see Appendix C. for full survey). The goal was to recommend their organization which field to spend a dedicated fund to mitigate workforce management challenges as an emergency response to the outbreak of Covid.

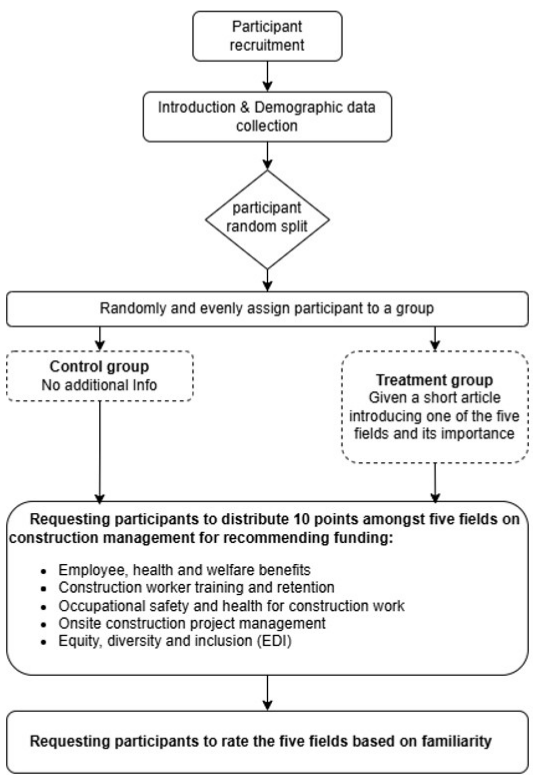

Figure 3.1: Experimental Design

There were Five emerging challenges in the field summarized in Table 3.1, which were

Vocational Training and Education for Construction Workers, Employee Benefits and Compensation, Occupational Safety and Health (OHS) for Construction Workers, Onsite Construction Project Management and Equity, Diversity, and Inclusion (EDI).Each of the five challenges was presented with a short description as an idea proposal contending for the fund. The descriptions included clear definitions of these ideas and explained their individual importance and benefits. Upon reading the proposal ideas, the participants were introduced to these five ideas by requested to read through them and were asked to rate their respective familiarity of the ideas on a Likert scale [33] from one to five. After setting up a clear understanding of the five ideas, participants were divided into the treatment groups and the control group evenly. The treatment group randomly received additional background information that appealed one of the five ideas to them as a means of randomly stimulating their subsequent availability, whereas the control group received no further background information. The participants were then asked to distribute ten points in total among the ideas for their recommendation. The idea with the highest score on recommendation points would be interpreted as the participants' recommended idea and the idea with the highest score on familiarity would be their inherently most available idea. Finally, demographic information and professional background information were collected during the end of the survey for analysis contingent to hypothesis 4.

The experimental treatment in this experiment was the the stochastic stimulation of the participant's availability. Availability here is defined as the ease of recollecting supportive information of an idea to select it as the recommendation. Correspondingly, the presumed effect of the availability heuristic would be for the participants to distribute the highest points towards the idea that they rated the highest in familiarity. To mitigate inherent availabilities, the treatment provides background information enclosing a short paragraph emphasizing the significance and benefits of a specific idea, which would stochastically disturb the availabilities of the participants. The treated participants would have the availability of one of the ideas enhanced and be relieved of their inherent availability. As such, the treatment would work as a mitigation strategy against possible effects of the availability heuristic.

Table 3.1: Literature overview of the five identified field of challenges in construction workforce management

Field	**Example of Studies in the Literature**	**Example of Challenges**
Employee health and welfare benefits	Health insurance & worker retention [34], [35]	According to CPWR's interview in 2019, almost 25% of U.S. construction workers are uninsured [36]
Construction worker training and retention	Factors affecting apprenticeship completion [37], skill gap bridging [38], worker retention & sustainability [39], demand forecasting [40] [41]	Construction predicted to need to hire roughly half a million additional workers in 2024 [8]
Occupational safety and health for construction work	Occupational safety [42], work-life balance & mental health [43] [44]	In 2023, there was 5,283 recorded fatal work-related injuries in construction, accounting for one in five occupational deaths occurred at all workplaces. [45]
Onsite construction project management	productivity [46], resource allocation [47] [48] [49], workforce management [50]	Majority of construction megaprojects face cost overruns of more than 30% in 2015. [51]
Equity, diversity and inclusion (EDI)	EDI on ethnicity and gender [52] [53]	According to OSHA's interview in 2022, 38% of interviewed workers report witnessing racial discrimination acts [54]

3.2 Participants

The experiment was devised in Qualtrics and distributed through multiple professional society networks including ASCE, DBIA Transportation and Infrastructure committee and LinkedIn reach outs in the United States. We were able to collect a total of 84 valid responses from professionals across 35 states, consisting of 16 control group and 68 treatment group participants. Participants were evenly distributed among the control group and five treatment groups that each corresponded to a specific idea. Our survey also collected the demographic information on the professional background information of the participants and contained comprehensive diversity across work type, professional roles, experience level and geolocations, which makes our sample pool a good representation of the AEC industry professionals in the United States.

Table 3.2: Participants Demographic Statistics

Group	Count	Experience	Count	Role	Count
Treatment	68	0–5 yrs	21	Contractor	15
		6–10 yrs	12	Consultant	19
		10–20 yrs	13	Owner	33
		20+ yrs	38	Owner Rep	0
				Developer	1
				Other	16
Control	16	0–5 yrs	6	Contractor	0
		6–10 yrs	1	Consultant	2
		10–20 yrs	4	Owner	7
		20+ yrs	5	Owner Rep	1
				Developer	0
				Other	6

CHAPTER 4

DATA ANALYSIS & RESULTS

4.1 Conditional Probability & Lift

In accordance with the experimental definition of the heuristic, a participant's highest familiarity is denoted as M, and the act of recommending an $idea_i$ while being most familiar with it $(i|M = i)$ is recognized as influenced by the availability heuristics. In the first part of data analysis, we investigated the statistical measures, including conditional probability and lift [55]. The prior probability of recommending an idea $P(i)$ was compared to the posterior probability $P(i|M = i)$ conditioned on the presence of the availability heuristic. The latter shows the probabilities of distributing the highest score to an idea whilst assigning highest familiarity score to the same idea, it reflects whether highest familiarity with an idea yields higher probability of recommending it. The comparison is demonstrated by lift,

$$lift = \frac{P(T|B)}{P(T)} = \frac{P(T, B)}{P(T)P(B)} \tag{4.1}$$

a common measure of performance in data mining to indicate enhanced response of target cases against the general population. For each of each respective ideas, their lifts are calculated as an indicator of the existence of the heuristic. An idea is believed to receive enhanced response as the most familiar idea from the participants if they return a lift greater than 1.

$$\frac{P(i|M = i)}{P(i)} > 1 \tag{4.2}$$

The probabilities and lifts were calculated respectively for the control group, the treatment group and the entire participant population as shown in Table 4.1. These results clearly show higher conditional probability as well as lifts greater than 1 in all fields among all groups. Worth mentioning, the treatment group does not show noticeable drop on lifts, which suggests that there might be no significant effect with the randomized strategy. Therefore, there is a stronger likelihood of favoring a specific idea given personal highest familiarity, which supports the hypothesis of availability heuristics at play and the indicates that the mitigation strategy might be ineffective.

Table 4.1: Conditional Probabilities and Lifts

Control Group	i=1	i=2	i=3	i=4	i=5
Pr(i)	21.88%	15.62%	15.62%	31.25%	15.62%
Pr(i | M=i)	66.67%	25.00%	25.00%	50.00%	33.33%
Pr(i | M=i)/Pr(i)	3.05	1.60	1.60	1.60	2.13
Treatment Group	i=1	i=2	i=3	i=4	i=5
Pr(i)	27.07%	10.53%	18.05%	27.82%	16.54%
Pr(i | M=i)	68.42%	29.63%	25.00%	64.29%	54.55%
Pr(i | M=i)/Pr(i)	2.53	2.81	1.39	2.31	3.30
All	i=1	i=2	i=3	i=4	i=5
Pr(i)	26.06%	11.52%	17.58%	28.48%	16.36%
Pr(i | M=i)	68.00%	29.03%	25.00%	62.50%	47.06%
Pr(i | M=i)/Pr(i)	2.61	2.52	1.42	2.19	2.88

4.2 T-test: Presence of availability heuristics

While lift indicate a stronger inclination to recommend an idea given maximum familiarity, it does not provide proof on statistical significance of familiarity and inclination. Hence, we further performed a standard T-test in a more intuitive manner to provide evidence for the hypothesis of the presence of availability heuristics on the entire sample pool.

By viewing responses of familiarity and recommendation score of an idea from each participant individually, each participant would contribute five $familiarity_i \leftrightarrow recommendation_i$ score value pair. We then partitioned the data points into two groups depending on their familiarity with the idea, which are having high familiarity (m_i>3) and low familiarity ($m_i \leq 3$), and performed T-test on the associated recommendation score to test the following null hypothesis.

Hypothesis. H0: The mean recommendation scores of individual ideas by participants of high familiarity and low familiarity are the same.

The result (see full results in Appendix. A) is significant with $p \leq 0.05$ as shown in Table 4.2. Therefore, we reject the null hypothesis and conclude that higher familiarity will have statistically higher recommendation scores, which established the statistical presence of availability heuristic here.

Table 4.2: Recommendation Score T-test Results

Results:	T-statistics: 3.425;	p-value: 0.00075.
Conclusion:	Reject null hypothesis.	

4.3 Two-Way ANOVA

Based on the results presented above, the general presence of availability heuristics has been substantiated. However, it remains plausible that the effects may vary significantly across individual judgments or decision contexts. Meanwhile, there is also a necessity to examine the significance of the treatment effect. In order to answer hypothesis two and three of whether the impact of availability heuristic is consistent among different topics and whether the exposure to random additional information mitigates the influences of the heuristic, this study conducted five idea-specific Two-way ANOVAs [56] to investigate the respective effects of the heuristic across context. In the literature [57] [58] [59] [60], usage of ordinal and categorical response in the experiment is applicable by normal distribution statistical inferences like ANOVA given sufficient categories (5 or more), and hence is applicable to our experiment design. The Two-way ANOVAs also combines idea specific familiarities of the participants as well as the treatment effect, making it capable of examining the significance of familiarity and the treatment concurrently. The data was grouped by the recommended ideas and divided into five Two-way ANOVA analysis. Each test incorporated eleven binary independent variables: five familiarity variables—where the highest familiarity score was coded as positive—one treatment variable coded as positive for the treated group, and five interaction variables, as specified in Equation 4.3. The dependent variable $Score_{reccomendation}$ is the distributed recommendation score of the chosen $idea_i$.

$$\begin{aligned} Score_{reccomendation} = {} & M_1 + M_2 + M_3 + M_4 + M_5 + Treatment \\ & + M_1 : Treatment + M_2 : Treatment + M_3 : Treatment \\ & + M_4 : Treatment + M_5 : Treatment + \epsilon \end{aligned} \tag{4.3}$$

Each of the five ANOVA tests on a proposed $idea_i$ on the following null hypothesis:

Hypothesis. H0: The mean recommendation scores of $idea_i$ given different familiarity (M) and treatment (T) are the same.

The results of all five tests are shown in detail in Appendix. A, and they show surprising coherency with the previous findings. All five tests indicated significant statistical correlation between the tested $idea_i$ and corresponding familiarity when $(M = i)$, where three of them are significant at $p<0.05$ and two of them are significant at $p<0.1$ (Fig.2). From Figure 4.1, we can see a clear diagonal significance pattern, which reflects higher correlations between the favoritism of each idea and their respective highest familiarity.

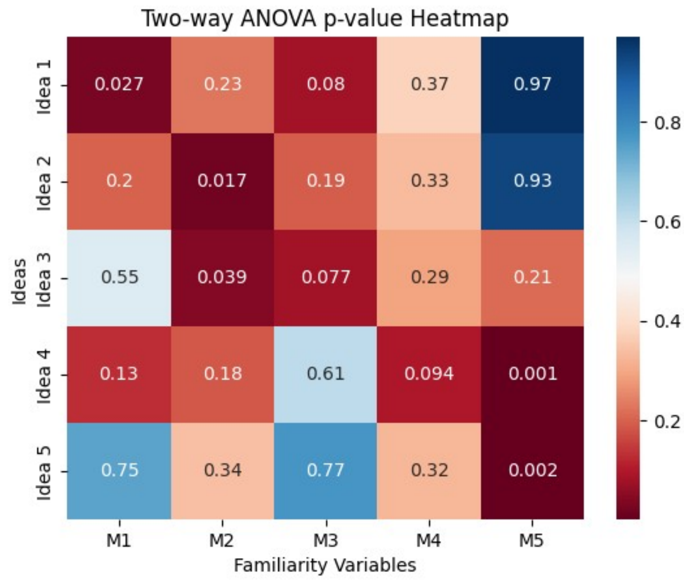

Figure 4.1: Two-way ANOVA Idea-Familiarity p-value Heatmap

Therefore, we reject part of the null hypothesis between familiarity and idea scores, and conclude that the mean of the recommendation score of ideas are statistically different given whether the participant is most familiar with the idea. While there are statistically significant results sparsely across the five tests for interactions and between different ideas, they do not hold enough consistency to form meaningful conclusions. Additionally, the treatment is also shown to be inconsistent upon different ideas, where the treatment achieved statistical significance on ideas two and three and was insignificant in others. This suggests that instead of completely failing to mitigate the effects of the heuristic, the randomized mitigation strategy might be susceptible to the characteristic of the field and possibly other factors.

4.4 Demographic ANOVA & Dimensionality Reduction

The results provide substantial evidence that the AEC professional community is influenced by the availability heuristic across various contexts. However, this raises the question of which individuals may be more susceptible to its effects. An analysis of the entire sample pool does not eliminate the possibility that a specific subgroup is driving the statistical behavior observed in the overall dataset. Therefore, this paper further attempts to identify significant factors contributing to the susceptibility of the heuristic from the professional background information collected. From the survey, several crucial demographic and professional features were collected:

- Experience level
- Professional role
- Geographic location

These three features characterize the background of a personnel in the AEC industry with reasonable comprehensiveness. For the sake of analysis, responses were converted into categorical variables to better capture the variance in them. There are uniquely eight different fields of expertise, four experience levels and five geographic locations as shown in Table 4.3.

Table 4.3: Demographic & Professional Background Features

Experience Level	**Professional Roles**	**Geo Location**
0-5 years	Developer	Northeast/East
6-10 years	Owner	West
11-20 years	Owner adviser	South
20+ years	Design consultant	Midwest
	Specialty consultant	Multiple
	General contractor	
	Construction specialist	
	Others	

This analysis also applies Two-way ANOVA for the benefits of examining the effects of demographic features and the treatment together, but it alternatively applies the familiarity score of the chosen idea as the dependent variable. This is to better reflect availability heuristic since the consistency of the heuristic among ideas were established. By using familiarity score of the highest rated idea (the chosen idea) as the dependent variable, the analysis can avoid recalculating the test for each of the ideas and have one unified test for each of the features. Therefore, there are three respective ANOVA tests performed that investigated the following null hypothesis for each of the three demographic features respectively:

Hypothesis. H0: The chosen familiarity scores given the different features and treatment are the same.

Hypothesis. H0: There are no interactions between the treatment and the different background of AEC professionals.

The results from Table 4.4-4.6 indicated that all three kinds of demographic features have no significance on the effects of the heuristic (see full results in Appendix. B), and there is no consistent significant interaction between them and the treatment effect except for geographic location being solely significant with $p<0.05$ in Table 4.6. Hence, we reject both null hypothesis and conclude that demographic characteristics have no significant effects on neither the effects of the heuristic nor the treatment effect.

Table 4.4: Professional Roles & Treatment Two-way ANOVA Statistics

	Df	Sum of Sq.	Mean of Sq.	F-value	Pr(¿F)
Field	7	16.15	2.301	1.607	0.148
Treated	1	0.86	0.864	0.602	0.440
Field:Treated	5	2.65	0.530	0.369	0.868
Residuals	70	100.48	1.435		

Table 4.5: Geographic Location & Treatment Two-way ANOVA Statistics

	Df	Sum of Sq.	Mean of Sq.	F-value	Pr(¿F)
Geo Location	4	2.52	0.630	0.487	0.74556
Treated	1	0.19	0.191	0.147	0.70237
Geo:Treated	4	21.56	5.389	4.159	0.00429
Residuals	74	95.88	1.296		

Furthermore, this paper performed t-SNE [61], a dimensionality reduction technique, to visualize and determine the significance of demographic features on the effects of the availability heuristic. Geo location and Professional role were one-hot encoded and Experience level was nominal encoded. The encoded vectors were then concatenated into

Table 4.6: Experience Levels & Treatment Two-way ANOVA Statistics

	Df	Sum of Sq.	Mean of Sq.	F-value	Pr(¿F)
Experience	1	0.26	0.262	0.178	0.674
Treated	1	0.19	0.191	0.130	0.720
Experience:Treated	1	1.92	1.923	1.306	0.256
Residuals	80	117.77	1.4721		

one-dimensional feature vectors for each of the responses. The algorithm had a randomized initialization and mapped the high-dimensional feature vectors onto a 2-D plane as shown in Figure 4.2. The figure manifests close proximity between the data points affected availability heuristic and those that are not.It showed no discernable discrepancy on the 2-D plane.

Combining the insignificant results from the demographic ANOVA analysis and the inseparability in 2-D mapping, we draw the conclusion that demographic characteristics are not significant factors of either the susceptibility of availability heuristic or the effectiveness of the mitigation strategy among AEC professionals .

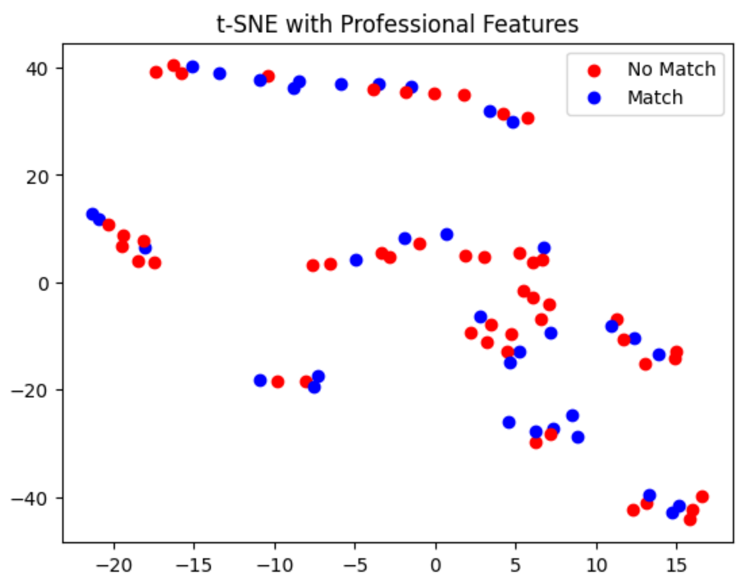

Figure 4.2: Dimensionality Reduced 2-D mapping of demographic features

CHAPTER 5
DISCUSSION

This study represents a significant step and as one of the firsts to investigate cognitive biases within the Architecture, Engineering, and Construction (AEC) professional community, moving beyond foundational work with student populations [27]. By focusing specifically on the availability heuristic among experienced practitioners, this research bridges a critical gap in the literature, which has extensively developed decision-making frameworks but seldom examined the underlying cognitive factors influencing their application by industry professionals.

The implications of these findings for the AEC industry are substantial. The demonstrated prevalence of the availability heuristic suggests the potential for unnoticed, yet systematic, flaws in critical decision-making processes across the sector. Reliance on easily recalled information over objective data can unconsciously skew judgments in areas vital to project success, including cost management, project scheduling, resource allocation, safety protocols, construction management, and even the formulation of governmental policies impacting the industry. Decisions concerning workforce management—the specific focus of this study's experimental design—are clearly susceptible, potentially leading to suboptimal strategies in critical fields such as training, retention, safety, and fostering equity, diversity, and inclusion. The consistency of the heuristic's effect across various demographic and professional variables underscores that this is not an issue confined to inexperienced individuals or specific disciplines, but rather a widespread phenomenon within the industry.

These results align with and extend previous research exploring cognitive biases in professional settings, although such studies remain relatively scarce within the AEC context. While decision-support systems exist, their effectiveness can be limited by the inherent biases of the humans employing them. This study's focus on the availability heuristic offers a specific mechanism through which decision errors may arise, moving beyond general observations of bias. The failure of the information exposure mitigation strategy, while perhaps disappointing from a practical standpoint, provides valuable insight, suggesting that more targeted or structured de-biasing techniques may be necessary.

Limitations and Future Research

We acknowledge certain limitations in this study, primarily concerning the sample size. While rigorous statistical analyses (including t-tests and ANOVA) confirmed the significance of our findings, the participant pool consisted of 84 AEC professionals. Recruiting large numbers of experienced professionals for research purposes presents significant practical challenges due to their demanding schedules and the logistical complexities of reaching a specialized population dispersed across various firms and locations.

However, it is important to contextualize this sample size. While quantitative studies often strive for larger numbers to maximize statistical power, the adequacy of a sample size also depends on the research question, population characteristics, and the depth of analysis. Research targeting niche professional groups often contends with smaller sample sizes compared to general population studies. Furthermore, we emphasize the richness of high-quality data in this study from smaller, well-selected samples. While 84 participants might be considered small by some quantitative standards, the sample achieved significant diversity in terms of professional roles, experience levels, and geographic representation across the United States, enhancing the potential relevance of the findings. The consistency and statistical significance of the results observed across this diverse group lend weight to the conclusions drawn.

This study serves as a crucial stepping stone. Future research should aim to replicate and extending these findings, potentially with larger or more targeted samples within specific AEC sub-sectors. Investigating the impact of other cognitive biases (e.g., confirmation bias, anchoring bias) prevalent in AEC decision-making is essential. Crucially, future work must focus on developing and testing effective mitigation strategies tailored to the AEC context, moving beyond simple information exposure to explore structured decision protocols, awareness training, and technologically aided de-biasing tools. Understanding and addressing cognitive biases holds significant potential for optimizing planning, improving project outcomes, and fostering more rational and robust decision-making throughout the AEC industry.

CHAPTER 6
CONCLUSION

This study provides significant empirical evidence demonstrating the consistent presence of the availability heuristic within the decision-making processes of Architecture, Engineering, and Construction (AEC) professionals in the United States. We established that familiarity with a workforce management concept directly increases its perceived importance in resource allocation decisions. A key finding is the pervasiveness of this heuristic, influencing decisions regardless of the professionals' years of experience, specific field of expertise, geographic location, or the particular decision topic under consideration. Furthermore, the research indicates that simply exposing professionals to diverse, arbitrary information does not effectively mitigate the influence of this cognitive bias. This finding challenges intuitive mitigation strategies and highlights the deeply ingrained nature of heuristic-based thinking. The primary contribution of this paper is the robust, statistically significant evidence demonstrating the existence and operation of the availability heuristic in the decision-making processes of AEC professionals across the United States.

These counterintuitive result suggest the heuristic is a deeply ingrained cognitive tendency within the profession, not confined to particular subgroups or knowledge areas, highlighting its potential ubiquity. Another key contribution lies in the evaluation of a potential mitigation strategy. We tested whether simply enhancing exposure to diverse information could counteract the bias. The results indicate that this intuitive approach is largely ineffective, providing valuable insight for the future development of more robust de-biasing techniques.

In summary, this study provides the first empirical confirmation of the availability heuristic among seasoned AEC professionals, establishes its widespread nature independent of common professional variables, and challenges a simple informational approach to mitigation. These findings underscore the importance of considering cognitive biases in AEC decision-making and position this work as a crucial starting point for a broader investigation into how heuristics shape industry practices. Future research should build upon this by exploring other cognitive biases and focusing on creating and validating effective, targeted strategies to promote more objective decision-making in the AEC sector.

Appendices

APPENDIX A

T-TEST AND TOPIC TWO-WAY ANOVA

ANOVA Analysis

T-test

```
t_high <- read.csv('ttest_high.csv') # familiarity>2
t_low <- read.csv('ttest_low.csv') # familiarity<=2
t.test(t_high$Score, mu = mean(t_low$Score))
```

```
##
##  One Sample t-test
##
## data:  t_high$Score
## t = 3.4246, df = 200, p-value = 0.0007469
## alternative hypothesis: true mean is not equal to 1.83105
## 95 percent confidence interval:
##  1.980806 2.387353
## sample estimates:
## mean of x
##   2.18408
```

Two-Way ANOVA Across Topics: idea recommendation score as output

From the definition of availability heuristics–a mental shortcut that relies on the ease immediate examples that comes to a given person's mind when evaluating a specific topic, concept, method, or decision, we are quantifying as follows:

1. The ease of recollection –> Familiarity score;
2. Taken shortcut or not –> Chosen the most familiar idea or not.
   As such, also following the ANOVA analysis in the previous paper, we can quantify the effectiveness of the heuristics with the continuous variable– Recommendation score of the chosen idea

Independent Variables(Binary): M_1-M_5, Treated
Dependent Variable (Familiarity score of the chosen idea): chosen_score = 1 - 10

5 In-group ANOVAs

```
my_data_in = read.csv("IngroupANOVA.csv")
print(names(my_data_in))
```

```
##  [1] "X"                  "i"                  "M_1"
##  [4] "M_2"                "M_3"                "M_4"
##  [7] "M_5"                "Treated"            "chosen_familiarity"
## [10] "Familiarity.1"      "Familiarity.2"      "Familiarity.3"
## [13] "Familiarity.4"      "Familiarity.5"      "Score.1"
## [16] "Score.2"            "Score.3"            "Score.4"
## [19] "Score.5"
```

```
res.aov2 <- aov(Score.1 ~ M_1 + M_2 + M_3 + M_4 + M_5 + Treated + M_1:Treated + M_2:Treated + M_
3:Treated + M_4:Treated + M_5:Treated , data = my_data_in)
summary(res.aov2)
```

```
##              Df Sum Sq Mean Sq F value  Pr(>F)
## M_1           1   8.39   8.386   5.043 0.02681 *
## M_2           1   2.46   2.461   1.480 0.22652
## M_3           1   5.19   5.188   3.120 0.08025 .
## M_4           1   1.33   1.325   0.797 0.37400
## M_5           1   0.00   0.002   0.001 0.96976
## Treated       1   0.60   0.599   0.360 0.54975
## M_1:Treated   1   5.44   5.438   3.270 0.07341 .
## M_2:Treated   1   0.10   0.100   0.060 0.80667
## M_3:Treated   1   0.09   0.091   0.055 0.81549
## M_4:Treated   1  16.65  16.647  10.012 0.00204 **
## M_5:Treated   1   0.09   0.095   0.057 0.81158
## Residuals   105 174.59   1.663
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
print(res.aov2$coefficients)
```

```
## (Intercept)         M_1         M_2         M_3         M_4         M_5
##  2.90395567  1.74724598 -0.66263550 -0.41713758 -2.09740759  0.18408496
##     Treated M_1:Treated M_2:Treated M_3:Treated M_4:Treated M_5:Treated
## -1.09313185 -1.43986039  0.35570057 -0.09502522  2.22476566  0.17580250
```

```
res.aov2 <- aov(Score.2 ~ M_1 + M_2 + M_3 + M_4 + M_5 + Treated + M_1:Treated + M_2:Treated + M_
3:Treated + M_4:Treated + M_5:Treated , data = my_data_in)
summary(res.aov2)
```

```
##              Df Sum Sq Mean Sq F value  Pr(>F)
## M_1           1   2.64   2.645   1.667 0.19954
## M_2           1   9.35   9.354   5.895 0.01688 *
## M_3           1   2.70   2.704   1.704 0.19463
## M_4           1   1.51   1.514   0.954 0.33090
## M_5           1   0.01   0.013   0.008 0.92907
## Treated       1   8.28   8.285   5.221 0.02432 *
## M_1:Treated   1   1.19   1.185   0.747 0.38945
## M_2:Treated   1   3.97   3.972   2.503 0.11662
## M_3:Treated   1   1.57   1.565   0.987 0.32286
## M_4:Treated   1  17.96  17.960  11.318 0.00107 **
## M_5:Treated   1   0.10   0.105   0.066 0.79762
## Residuals   105 166.61   1.587
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
print(res.aov2$coefficients)
```

```
## (Intercept)         M_1         M_2         M_3         M_4         M_5
##   1.4268124  -1.2657490   0.2945096  -0.1698586   1.5926691  -0.2347237
##     Treated M_1:Treated M_2:Treated M_3:Treated M_4:Treated M_5:Treated
##   1.4508354   0.9560556   0.8868081   0.5925107  -2.3100932  -0.1847407
```

```
res.aov2 <- aov(Score.3 ~ M_1 + M_2 + M_3 + M_4 + M_5 + Treated + M_1:Treated + M_2:Treated + M_
3:Treated + M_4:Treated + M_5:Treated , data = my_data_in)
summary(res.aov2)
```

```
##              Df Sum Sq Mean Sq F value Pr(>F)
## M_1           1   0.39   0.394   0.359 0.5506
## M_2           1   4.83   4.825   4.392 0.0385 *
## M_3           1   3.50   3.500   3.186 0.0771 .
## M_4           1   1.25   1.249   1.137 0.2887
## M_5           1   1.73   1.729   1.574 0.2124
## Treated       1   5.16   5.156   4.693 0.0325 *
## M_1:Treated   1   0.00   0.002   0.002 0.9636
## M_2:Treated   1   4.56   4.558   4.149 0.0442 *
## M_3:Treated   1   1.22   1.217   1.108 0.2949
## M_4:Treated   1   6.47   6.466   5.886 0.0170 *
## M_5:Treated   1   0.03   0.034   0.031 0.8601
## Residuals   105 115.35   1.099
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
print(res.aov2$coefficients)
```

```
## (Intercept)         M_1         M_2         M_3         M_4         M_5 
##  0.58580883 -0.06321599  0.35667011  0.97787990  1.49064403  0.04386640 
##     Treated M_1:Treated M_2:Treated M_3:Treated M_4:Treated M_5:Treated 
##  0.82049816  0.17804560 -1.21422742 -0.66997860 -1.45916437  0.10567143
```

```
res.aov2 <- aov(Score.4 ~ M_1 + M_2 + M_3 + M_4 + M_5 + Treated + M_1:Treated + M_2:Treated + M_
3:Treated + M_4:Treated + M_5:Treated , data = my_data_in)
summary(res.aov2)
```

```
##              Df Sum Sq Mean Sq F value   Pr(>F)    
## M_1           1   5.27   5.275   2.343 0.128837    
## M_2           1   4.03   4.033   1.791 0.183635    
## M_3           1   0.58   0.579   0.257 0.613086    
## M_4           1   6.42   6.416   2.850 0.094340 .  
## M_5           1  25.89  25.893  11.502 0.000981 ***
## Treated       1   3.45   3.451   1.533 0.218419    
## M_1:Treated   1   0.89   0.889   0.395 0.531147    
## M_2:Treated   1   0.42   0.417   0.185 0.667630    
## M_3:Treated   1   1.95   1.946   0.864 0.354641    
## M_4:Treated   1   3.14   3.143   1.396 0.240035    
## M_5:Treated   1   0.07   0.066   0.029 0.864880    
## Residuals   105 236.37   2.251                     
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
print(res.aov2$coefficients)
```

```
## (Intercept)         M_1         M_2         M_3         M_4         M_5 
##   3.1162075  -0.3546692   0.1332483  -0.7519295  -0.4924910  -0.8060643 
##     Treated M_1:Treated M_2:Treated M_3:Treated M_4:Treated M_5:Treated 
##  -0.6690793   0.2846815   0.3106027   0.8130281   1.0417695  -0.1460066
```

```
res.aov2 <- aov(Score.5 ~ M_1 + M_2 + M_3 + M_4 + M_5 + Treated + M_1:Treated + M_2:Treated + M_
3:Treated + M_4:Treated + M_5:Treated , data = my_data_in)
summary(res.aov2)
```

```
##                Df Sum Sq Mean Sq F value  Pr(>F)
## M_1             1   0.17   0.171   0.108 0.74314
## M_2             1   1.46   1.465   0.924 0.33861
## M_3             1   0.13   0.133   0.084 0.77230
## M_4             1   1.56   1.564   0.987 0.32285
## M_5             1  15.68  15.676   9.889 0.00216 **
## Treated         1   3.19   3.186   2.010 0.15927
## M_1:Treated     1   0.06   0.059   0.037 0.84716
## M_2:Treated     1   0.64   0.638   0.402 0.52725
## M_3:Treated     1   1.39   1.388   0.876 0.35155
## M_4:Treated     1   0.94   0.936   0.590 0.44395
## M_5:Treated     1   0.02   0.021   0.013 0.90783
## Residuals     105 166.45   1.585
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
print(res.aov2$coefficients)
```

```
## (Intercept)         M_1         M_2         M_3         M_4         M_5
##  1.96721564 -0.06361178 -0.12179248  0.36104576 -0.49341454  0.81283669
##     Treated M_1:Treated M_2:Treated M_3:Treated M_4:Treated M_5:Treated
## -0.55640088  0.01606211 -0.32716097 -0.61429424  0.51349246  0.08335701
```

APPENDIX B

DEMOGRAPHIC TWO-WAY ANOVA

Two-WAY ANOVA Demographic

2023-09-28

R Markdown

```
Exp_data = read.csv("ExpANOVA.csv")
print(names(Exp_data))
```

```
## [1] "X"                  "chosen_familiarity" "Treated"
## [4] "Experience_Level"
```

```
exp.aov2 <- aov(chosen_familiarity ~ Treated + Experience_Level+ Experience_Level:Treated, data
= Exp_data)
summary(exp.aov2)
```

```
##                          Df Sum Sq Mean Sq F value Pr(>F)
## Treated                   1   0.19  0.1907   0.130  0.720
## Experience_Level          1   0.26  0.2623   0.178  0.674
## Treated:Experience_Level  1   1.92  1.9229   1.306  0.256
## Residuals                80 117.77  1.4721
```

```
Field_data = read.csv("FieldANOVA.csv")
print(names(Field_data))
```

```
## [1] "X"                  "Field"              "chosen_familiarity"
## [4] "Treated"
```

```
field.aov2 <- aov(chosen_familiarity ~ Field + Treated + Treated:Field, data = Field_data)
summary(field.aov2)
```

```
##               Df Sum Sq Mean Sq F value Pr(>F)
## Field          7  16.15  2.3071   1.607  0.148
## Treated        1   0.86  0.8644   0.602  0.440
## Field:Treated  5   2.65  0.5300   0.369  0.868
## Residuals     70 100.48  1.4354
```

```
Geo_data = read.csv("Geo_LocationANOVA.csv")
print(names(Geo_data))
```

```
## [1] "X"                  "Geo_Location"       "chosen_familiarity"
## [4] "Treated"
```

```
geo.aov2 <- aov(chosen_familiarity ~ Treated+Geo_Location+Treated:Geo_Location, data = Geo_data)

summary(geo.aov2)
```

```
##                      Df Sum Sq Mean Sq F value  Pr(>F)
## Treated               1   0.19   0.191   0.147 0.70237
## Geo_Location          4   2.52   0.630   0.487 0.74556
## Treated:Geo_Location  4  21.56   5.389   4.159 0.00429 **
## Residuals            74  95.88   1.296
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

APPENDIX C

EXPERIMENT SURVEY

The full Qualtrix experiment survey.

Tools Saved Nov 7, 2022 at 1:11 PM Draft Preview Publish

Phase2_official ExpertReview score Fair

Question Block A

Cover Letter

CONSENT TO PARTICIPATE IN A RESEARCH STUDY
Decision-making on transportation construction workforce under COVID-19 uncertainties
Georgia Institute of Technology and University of Texas at Arlington

Dear Participants,

The purpose of this study is to better understand opinions about emerging trends and challenges affecting workforce decision making in the construction industry as the results of the COVID-19 pandemic. The findings of this study will benefit decision-makers in the construction industry with better understanding on the impacts caused by the COVID-19 pandemic. There are no costs to you, other than your time, for being in this study. The risks or discomforts involved are no greater than those involved in daily activities such as email correspondence or user registration via a secure website. We will comply with any applicable laws and regulations regarding confidentiality. Your name will not appear when the results of this study are presented or published. Your participation in this study is voluntary. You have the right to change your mind and leave the study at any time without giving any reason and without penalty. If would like to be a volunteer in this research study please continue with the survey.

It is expected that the survey will take just 10 minutes of your time. If you have any questions about the survey, you may contact Baabak Ashuri at baabak@gatech.edu or (404) 385-7608.

Thank you,

Baabak Ashuri, Professor, Georgia Tech
Mohsen Shahandashti, Associate Professor, University of Texas at Arlington (UTA)

Page Break

Q11

What best describes your primary background?

- ◯ Owner agency employee (i.e., Department of Transportation staff)
- ◯ Owner adviser (or Owner Rep.)
- ◯ Design consultant
- ◯ Specialty sub-consultant
- ◯ General contractor
- ◯ Specialty contractor
- ◯ Developer
- ◯ Construction engineering and inspection (CEI) specialist
- ◯ Other (please specify)

Q12

What is your current role or job title?

Q14

In what state(s) do you have the most experience in this role? (select all that apply)

- ☐ Alabama
- ☐ Alaska
- ☐ Arizona
- ☐ Arkansas
- ☐ California
- ☐ Colorado
- ☐ Connecticut
- ☐ Delaware
- ☐ District of Columbia
- ☐ Florida
- ☐ Georgia
- ☐ Hawaii
- ☐ Idaho
- ☐ Illinois
- ☐ Indiana
- ☐ Iowa
- ☐ Kansas
- ☐ Kentucky
- ☐ Louisiana
- ☐ Maine

- ☐ Maryland
- ☐ Massachusetts
- ☐ Michigan
- ☐ Minnesota
- ☐ Mississippi
- ☐ Missouri
- ☐ Montana
- ☐ Nebraska
- ☐ Nevada
- ☐ New Hampshire
- ☐ New Jersey
- ☐ New Mexico
- ☐ New York
- ☐ North Carolina
- ☐ North Dakota
- ☐ Ohio
- ☐ Oklahoma
- ☐ Oregon
- ☐ Pennsylvania
- ☐ Puerto Rico
- ☐ Rhode Island
- ☐ South Carolina
- ☐ South Dakota
- ☐ Tennessee
- ☐ Texas
- ☐ Utah
- ☐ Vermont
- ☐ Virginia
- ☐ Washington
- ☐ West Virginia
- ☐ Wisconsin
- ☐ Wyoming
- ☐ I do not reside in the United States

Q15 *

How many years of experience do you have in the transportation industry?

- ○ 0-5 years
- ○ 6-10 years
- ○ 11-20 years
- ○ 20+ years

Page Break

BK1

Background Information: Please read the paragraph below.

Finding skilled workers is a significant challenge faced by the US construction industry in recent years. A 2018 survey by Autodesk and the Associated General Contractors of America (AGC) shows that 80% of contractors report difficulty finding qualified craft workers to hire. In August 2020, the survey was conducted again with 2,000 participating firms. The results show that even though 60% of firms report that future projects have been canceled or delayed during the pandemic, 52% of firms still have a hard time finding craft workers. An update released in September 2021 shows that the shortage has reached pre-pandemic levels even as coronavirus continues to impact projects and disrupt supply chains. Apprenticeship programs, a critical pipeline for craft workers, are significantly disrupted by the pandemic: apprenticeship curriculums normally comprise large parts of in-person training and are more difficult to deliver in distant learning mode. The required technical construction skills are changing due to the construction industry transformation through prefabrication, automation, and e-construction.

Page Break

Introduction

Description of a hypothetical decision-making scenario: Suppose that your organization recently set up a dedicated fund for emergency response in the wake of a pandemic. The fund aims to support initiatives with greatest potential to mitigate emerging workforce management challenges since the outbreak of pandemic. As the first step, all employees are invited to submit their ideas. Shortlisted ideas will be considered for funding support. You, as one of the invited reviewers, are about to read five submitted ideas. Afterwards, you need to give your recommendations.

Page Break

RA

Please review the following proposal ideas:

"**Idea 1:** Set up a dedicated taskforce to review and update employee paid sick leave policy and family leave wages, with consideration of the impacts of COVID-19. Include appropriate health insurance as part of employee benefits package. Educate employees on their rights and protections associated with mental health. Provide necessary counselling services. Review employee payment and make necessary changes to ensure its attractiveness to construction workers.

Idea 2: Enhance existing workforce training to accommodate the new normal after COVID-19, such as strengthening training related to prefabrication, modular construction, construction automation, and digitalization of documents. Transform existing apprenticeship curriculums to ensure health and safety of the participants, while complying with the educational standards, for example, designing take-home kits or turning group projects into individual projects.

Idea 3: Evolve existing safety training and induction to overcome the widespread "vaccine hesitancy". COVID-related safety factors are important and must be continued. But there are several other health and safety issues in the construction job site that should not be overlooked. Heighten awareness of critical safety issues, such as falls and slips, by ensuring necessary time in daily induction, using obvious visual aids for spacing location, walkway, and scaffold.

Idea 4: Enhance existing planning and scheduling to increase productivity and mitigate the impacts of the pandemic, as well as associated supply chain disorder, on schedule. Streamline construction sites: more space, less overlap of trades, less double handing of materials, and fewer “hanging around” people. Introduce flexible shifts to maximize the use of equipment and involve more workers while avoiding large crowds congregating.

Idea 5: Provide dedicated training on diversity, equity, and inclusion, with focus on jobsite. Set up a safe environment to let workers report racist actions. Have a system to track incidents, and make firm disciplinary actions against the violators. Ensure various resources including professional training are equally reached to minority workers."

Q16

You are given 10 points to distribute among the ideas. Make sure the sum of points you give to ideas 1-5 is equal to 10. Please grade each idea (maximum possible grade = 10)

Idea 1	0
Idea 2	0
Idea 3	0
Idea 4	0
Idea 5	0
Total	0

Page Break

Q17

Please rate your familiarity with respect to the following five fields (1 = least familiar; 5 = most familiar)

	1	2	3	4	5
Vocational Training and Education for Construction Workers	○	○	○	○	○
Employee Benefits and Compensation	○	○	○	○	○
Occupational Safety and Health for Construction Workers	○	○	○	○	○
Onsite Construction Project Management	○	○	○	○	○
Equity, Diversity, and Inclusion (EDI)	○	○	○	○	○

Import from library

Add new question

Question Block F

Q195

CONSENT TO PARTICIPATE IN A RESEARCH STUDY
Decision-making on transportation construction workforce under COVID-19 uncertainties
Georgia Institute of Technology and University of Texas at Arlington

Dear Participants,

The purpose of this study is to better understand opinions about emerging trends and challenges affecting workforce decision making in the construction industry as the results of the COVID-19 pandemic. The findings of this study will benefit decision-makers in the construction industry with better understanding on the impacts caused by the COVID-19 pandemic. There are no costs to you, other than your time, for being in this study. The risks or discomforts involved are no greater than those involved in daily activities such as email correspondence or user registration via a secure website. We will comply with any applicable laws and regulations regarding confidentiality. Your name will not appear when the results of this study are presented or published. Your participation in this study is voluntary. You have the right to change your mind and leave the study at any time without giving any reason and without penalty. If would like to be a volunteer in this research study please continue with the survey.

It is expected that the survey will take just 10 minutes of your time. If you have any questions about the survey, you may contact Baabak Ashuri at baabak@gatech.edu or (404) 385-7608.

Thank you,

Baabak Ashuri, Professor, Georgia Tech
Mohsen Shahandashti, Associate Professor, University of Texas at Arlington (UTA)

Page Break

Q196 *

What best describes your primary background?

- ◯ Owner agency employee (i.e., Department of Transportation staff)
- ◯ Owner adviser (or Owner Rep.)
- ◯ Design consultant
- ◯ Specialty sub-consultant
- ◯ General contractor
- ◯ Specialty contractor
- ◯ Developer
- ◯ Construction engineering and inspection (CEI) specialist
- ◯ Other (please specify)

Q197

What is your current role or job title?

Q198

In what state(s) do you have the most experience in this role? (select all that apply)

- [ ] Alabama
- [ ] Alaska
- [ ] Arizona
- [ ] Arkansas
- [ ] California
- [ ] Colorado
- [ ] Connecticut
- [ ] Delaware
- [ ] District of Columbia
- [ ] Florida
- [ ] Georgia
- [ ] Hawaii
- [ ] Idaho
- [ ] Illinois
- [ ] Indiana
- [ ] Iowa
- [ ] Kansas
- [ ] Kentucky
- [ ] Louisiana
- [ ] Maine
- [ ] Maryland
- [ ] Massachusetts
- [ ] Michigan
- [ ] Minnesota
- [ ] Mississippi
- [ ] Missouri
- [ ] Montana
- [ ] Nebraska
- [ ] Nevada
- [ ] New Hampshire
- [ ] New Jersey
- [ ] New Mexico
- [ ] New York
- [ ] North Carolina

- ☐ North Dakota
- ☐ Ohio
- ☐ Oklahoma
- ☐ Oregon
- ☐ Pennsylvania
- ☐ Puerto Rico
- ☐ Rhode Island
- ☐ South Carolina
- ☐ South Dakota
- ☐ Tennessee
- ☐ Texas
- ☐ Utah
- ☐ Vermont
- ☐ Virginia
- ☐ Washington
- ☐ West Virginia
- ☐ Wisconsin
- ☐ Wyoming
- ☐ I do not reside in the United States

Q199 *

How many years of experience do you have in the transportation industry?

- ○ 0-5 years
- ○ 6-10 years
- ○ 11-20 years
- ○ 20+ years

Page Break

Q201

Description of a hypothetical decision-making scenario: Suppose that your organization recently set up a dedicated fund for emergency response in the wake of a pandemic. The fund aims to support initiatives with greatest potential to mitigate emerging workforce management challenges since the outbreak of pandemic. As the first step, all employees are invited to submit their ideas. Shortlisted ideas will be considered for funding support. You, as one of the invited reviewers, are about to read five submitted ideas. Afterwards, you need to give your recommendations.

Page Break

Q202

Please review the following proposal ideas:

"**Idea 1:** Set up a dedicated taskforce to review and update employee paid sick leave policy and family leave wages, with consideration of the impacts of COVID-19. Include appropriate health insurance as part of employee benefits package. Educate employees on their rights and protections associated with mental health. Provide necessary counselling services. Review employee payment and make necessary changes to ensure its attractiveness to construction workers.

Idea 2: Enhance existing workforce training to accommodate the new normal after COVID-19, such as strengthening training related to prefabrication, modular construction, construction automation, and digitalization of documents. Transform existing apprenticeship curriculums to ensure health and safety of the participants, while complying with the educational standards, for example, designing take-home kits or turning group projects into individual projects.

Idea 3: Evolve existing safety training and induction to overcome the widespread "vaccine hesitancy". COVID-related safety factors are important and must be continued. But there are several other health and safety issues in the construction job site that should not be overlooked. Heighten awareness of critical safety issues, such as falls and slips, by ensuring necessary time in daily induction, using obvious visual aids for spacing location, walkway, and scaffold.

Idea 4: Enhance existing planning and scheduling to increase productivity and mitigate the impacts of the pandemic, as well as associated supply chain disorder, on schedule. Streamline construction sites: more space, less overlap of trades, less double handing of materials, and fewer “hanging around” people. Introduce flexible shifts to maximize the use of equipment and involve more workers while avoiding large crowds congregating.

Idea 5: Provide dedicated training on diversity, equity, and inclusion, with focus on jobsite. Set up a safe environment to let workers report racist actions. Have a system to track incidents, and make firm disciplinary actions against the violators. Ensure various resources including professional training are equally reached to minority workers."

Q203

You are given 10 points to distribute among the ideas. Make sure the sum of points you give to ideas 1-5 is equal to 10. Please grade each idea (maximum possible grade = 10)

Idea 1	0
Idea 2	0
Idea 3	0
Idea 4	0
Idea 5	0
Total	0

Page Break

Q204

Please rate your familiarity with respect to the following five fields (1 = least familiar; 5 = most familiar)

	1	2	3	4	5
Vocational Training and Education for Construction Workers	○	○	○	○	○
Employee Benefits and Compensation	○	○	○	○	○
Occupational Safety and Health for Construction Workers	○	○	○	○	○
Onsite Construction Project Management	○	○	○	○	○
Equity, Diversity, and Inclusion (EDI)	○	○	○	○	○

Import from library   Add new question

Question Block E

Q185

CONSENT TO PARTICIPATE IN A RESEARCH STUDY
Decision-making on transportation construction workforce under COVID-19 uncertainties
Georgia Institute of Technology and University of Texas at Arlington

Dear Participants,

The purpose of this study is to better understand opinions about emerging trends and challenges affecting workforce decision making in the construction industry as the results of the COVID-19 pandemic. The findings of this study will benefit decision-makers in the construction industry with better understanding on the impacts caused by the COVID-19 pandemic. There are no costs to you, other than your time, for being in this study. The risks or discomforts involved are no greater than those involved in daily activities such as email correspondence or user registration via a secure website. We will comply with any applicable laws and regulations regarding confidentiality. Your name will not appear when the results of this study are presented or published. Your participation in this study is voluntary. You have the right to change your mind and leave the study at any time without giving any reason and without penalty. If would like to be a volunteer in this research study please continue with the survey.

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Thank you,

Baabak Ashuri, Professor, Georgia Tech
Mohsen Shahandashti, Associate Professor, University of Texas at Arlington (UTA)

Page Break

Q186 *

What best describes your primary background?

- ○ Owner agency employee (i.e., Department of Transportation staff)
- ○ Owner adviser (or Owner Rep.)
- ○ Design consultant
- ○ Specialty sub-consultant
- ○ General contractor
- ○ Specialty contractor
- ○ Developer
- ○ Construction engineering and inspection (CEI) specialist
- ○ Other (please specify)

Q187

What is your current role or job title?

Q188

In what state(s) do you have the most experience in this role? (select all that apply)

- ☐ Alabama
- ☐ Alaska
- ☐ Arizona
- ☐ Arkansas
- ☐ California
- ☐ Colorado
- ☐ Connecticut
- ☐ Delaware
- ☐ District of Columbia
- ☐ Florida
- ☐ Georgia
- ☐ Hawaii
- ☐ Idaho
- ☐ Illinois
- ☐ Indiana
- ☐ Iowa
- ☐ Kansas
- ☐ Kentucky
- ☐ Louisiana
- ☐ Maine
- ☐ Maryland
- ☐ Massachusetts
- ☐ Michigan
- ☐ Minnesota
- ☐ Mississippi
- ☐ Missouri
- ☐ Montana
- ☐ Nebraska
- ☐ Nevada
- ☐ New Hampshire
- ☐ New Jersey
- ☐ New Mexico
- ☐ New York
- ☐ North Carolina

- ☐ North Dakota
- ☐ Ohio
- ☐ Oklahoma
- ☐ Oregon
- ☐ Pennsylvania
- ☐ Puerto Rico
- ☐ Rhode Island
- ☐ South Carolina
- ☐ South Dakota
- ☐ Tennessee
- ☐ Texas
- ☐ Utah
- ☐ Vermont
- ☐ Virginia
- ☐ Washington
- ☐ West Virginia
- ☐ Wisconsin
- ☐ Wyoming
- ☐ I do not reside in the United States

Q189 *

How many years of experience do you have in the transportation industry?

- ○ 0-5 years
- ○ 6-10 years
- ○ 11-20 years
- ○ 20+ years

Page Break

Q190

Background Information: Please read the paragraph below.

Construction employment patterns suggest racial disparities. A research by CPWR (the Center for Construction Research and Training) shows that "85% of racial minorities in construction worked in blue-collar occupations in 2010, while 76% of the construction workforce was employed in such occupations". Within the group of blue-collars, 26% of minority workers work as entry-level, unskilled laborers while the proportion among the overall construction workforce is 16%. At the onset of the pandemic, 19.8% of Hispanic workers lost their jobs while the proportion of non-Hispanic workers who lost their jobs was 12.7%. Researchers at University of Texas Austin found out that Latino workers, who have a higher incidence of respiratory and other illnesses, are especially susceptible to infection. ConstructionDive reported nearly 20 reported incidents of flagrant racism on construction jobsites from June to October 2020. The condition is not altered in 2021 - an update by ConstructionDive in August 2021 shows that 72% of Black respondents and 66% of women respondents noted that they had experienced discrimination or prejudice while at work.

Page Break

Q191

Description of a hypothetical decision-making scenario: Suppose that your organization recently set up a dedicated fund for emergency response in the wake of a pandemic. The fund aims to support initiatives with greatest potential to mitigate emerging workforce management challenges since the outbreak of pandemic. As the first step, all employees are invited to submit their ideas. Shortlisted ideas will be considered for funding support. You, as one of the invited reviewers, are about to read five submitted ideas. Afterwards, you need to give your recommendations.

Page Break

Q192

Please review the following proposal ideas:

"**Idea 1:** Set up a dedicated taskforce to review and update employee paid sick leave policy and family leave wages, with consideration of the impacts of COVID-19. Include appropriate health insurance as part of employee benefits package. Educate employees on their rights and protections associated with mental health. Provide necessary counselling services. Review employee payment and make necessary changes to ensure its attractiveness to construction workers.

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Idea 5: Provide dedicated training on diversity, equity, and inclusion, with focus on jobsite. Set up a safe environment to let workers report racist actions. Have a system to track incidents, and make firm disciplinary actions against the violators. Ensure various resources including professional training are equally reached to minority workers."

Q193

You are given 10 points to distribute among the ideas. Make sure the sum of points you give to ideas 1-5 is equal to 10. Please grade each idea (maximum possible grade = 10)

Idea 1	0
Idea 2	0
Idea 3	0
Idea 4	0
Idea 5	0
Total	0

Page Break

Q194

Please rate your familiarity with respect to the following five fields (1 = least familiar; 5 = most familiar)

	1	2	3	4	Click to write Scale Point 5
Vocational Training and Education for Construction Workers	○	○	○	○	○
Employee Benefits and Compensation	○	○	○	○	○
Occupational Safety and Health for Construction Workers	○	○	○	○	○
Onsite Construction Project Management	○	○	○	○	○
Equity, Diversity, and Inclusion (EDI)	○	○	○	○	○

Import from library

Add new question

Question Block D

Q175

CONSENT TO PARTICIPATE IN A RESEARCH STUDY
Decision-making on transportation construction workforce under COVID-19 uncertainties
Georgia Institute of Technology and University of Texas at Arlington

Dear Participants,

The purpose of this study is to better understand opinions about emerging trends and challenges affecting workforce decision making in the construction industry as the results of the COVID-19 pandemic. The findings of this study will benefit decision-makers in the construction industry with better understanding on the impacts caused by the COVID-19 pandemic. There are no costs to you, other than your time, for being in this study. The risks or discomforts involved are no greater than those involved in daily activities such as email correspondence or user registration via a secure website. We will comply with any applicable laws and regulations regarding confidentiality. Your name will not appear when the results of this study are presented or published. Your participation in this study is voluntary. You have the right to change your mind and leave the study at any time without giving any reason and without penalty. If would like to be a volunteer in this research study please continue with the survey.

It is expected that the survey will take just 10 minutes of your time. If you have any questions about the survey, you may contact Baabak Ashuri at baabak@gatech.edu or (404) 385-7608.

Thank you,

Baabak Ashuri, Professor, Georgia Tech
Mohsen Shahandashti, Associate Professor, University of Texas at Arlington (UTA)

Page Break

Q176 *

What best describes your primary background?

- ○ Owner agency employee (i.e., Department of Transportation staff)
- ○ Owner adviser (or Owner Rep.)
- ○ Design consultant
- ○ Specialty sub-consultant
- ○ General contractor
- ○ Specialty contractor
- ○ Developer
- ○ Construction engineering and inspection (CEI) specialist
- ○ Other (please specify)

Q177

What is your current role or job title?

Q178

In what state(s) do you have the most experience in this role? (select all that apply)

- ☐ Alabama
- ☐ Alaska
- ☐ Arizona
- ☐ Arkansas
- ☐ California
- ☐ Colorado
- ☐ Connecticut
- ☐ Delaware
- ☐ District of Columbia
- ☐ Florida
- ☐ Georgia
- ☐ Hawaii
- ☐ Idaho
- ☐ Illinois
- ☐ Indiana
- ☐ Iowa
- ☐ Kansas
- ☐ Kentucky
- ☐ Louisiana
- ☐ Maine
- ☐ Maryland
- ☐ Massachusetts
- ☐ Michigan
- ☐ Minnesota
- ☐ Mississippi
- ☐ Missouri
- ☐ Montana
- ☐ Nebraska
- ☐ Nevada
- ☐ New Hampshire
- ☐ New Jersey
- ☐ New Mexico
- ☐ New York
- ☐ North Carolina

- ☐ North Dakota
- ☐ Ohio
- ☐ Oklahoma
- ☐ Oregon
- ☐ Pennsylvania
- ☐ Puerto Rico
- ☐ Rhode Island
- ☐ South Carolina
- ☐ South Dakota
- ☐ Tennessee
- ☐ Texas
- ☐ Utah
- ☐ Vermont
- ☐ Virginia
- ☐ Washington
- ☐ West Virginia
- ☐ Wisconsin
- ☐ Wyoming
- ☐ I do not reside in the United States

Q179

How many years of experience do you have in the transportation industry?

- ◯ 0-5 years
- ◯ 6-10 years
- ◯ 11-20 years
- ◯ 20+ years

Page Break

Q180

Background Information: Please read the paragraph below.

A 2020 survey by Associated General Contractors of America (AGC) indicates that 78% of contractors have experienced project delays or disruptions since the outbreak of the pandemic. AGC reconducted the survey in February 2021, showing that 71% of contractors have experienced schedule delays. Shortage of construction materials, equipment, or parts (52%), shortage of craftworkers/subcontractors (32%), and potentially infected person visited jobsite (25%) are the top three reasons causing project delay or disruptions identified by interviewees. Schedule delay jeopardizes the success of construction projects by adding cost, legal claims, and greater risk exposure. According to the 2021 3Q cost report by Engineering News-Record (ENR), there is no end in sight to the year of supply chain chaos and materials challenges, which pose tremendous pressures on project cost and schedule management.

Page Break

Page Break

Q181

Description of a hypothetical decision-making scenario: Suppose that your organization recently set up a dedicated fund for emergency response in the wake of a pandemic. The fund aims to support initiatives with greatest potential to mitigate emerging workforce management challenges since the outbreak of pandemic. As the first step, all employees are invited to submit their ideas. Shortlisted ideas will be considered for funding support. You, as one of the invited reviewers, are about to read five submitted ideas. Afterwards, you need to give your recommendations.

Page Break

Q182

Please review the following proposal ideas:

"**Idea 1:** Set up a dedicated taskforce to review and update employee paid sick leave policy and family leave wages, with consideration of the impacts of COVID-19. Include appropriate health insurance as part of employee benefits package. Educate employees on their rights and protections associated with mental health. Provide necessary counselling services. Review employee payment and make necessary changes to ensure its attractiveness to construction workers.

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Q183

You are given 10 points to distribute among the ideas. Make sure the sum of points you give to ideas 1-5 is equal to 10. Please grade each idea (maximum possible grade = 10)

Idea 1	0
Idea 2	0
Idea 3	0
Idea 4	0
Idea 5	0
Total	0

Page Break

Q184

Please rate your familiarity with respect to the following five fields (1 = least familiar; 5 = most familiar)

	1	2	3	4	Click to write Scale Point 5
Vocational Training and Education for Construction Workers	○	○	○	○	○
Employee Benefits and Compensation	○	○	○	○	○
Occupational Safety and Health for Construction Workers	○	○	○	○	○
Onsite Construction Project Management	○	○	○	○	○
Equity, Diversity, and Inclusion (EDI)	○	○	○	○	○

Import from library

Add new question

Question Block B

Q155

CONSENT TO PARTICIPATE IN A RESEARCH STUDY
Decision-making on transportation construction workforce under COVID-19 uncertainties
Georgia Institute of Technology and University of Texas at Arlington

Dear Participants,

The purpose of this study is to better understand opinions about emerging trends and challenges affecting workforce decision making in the construction industry as the results of the COVID-19 pandemic. The findings of this study will benefit decision-makers in the construction industry with better understanding on the impacts caused by the COVID-19 pandemic. There are no costs to you, other than your time, for being in this study. The risks or discomforts involved are no greater than those involved in daily activities such as email correspondence or user registration via a secure website. We will comply with any applicable laws and regulations regarding confidentiality. Your name will not appear when the results of this study are presented or published. Your participation in this study is voluntary. You have the right to change your mind and leave the study at any time without giving any reason and without penalty. If would like to be a volunteer in this research study please continue with the survey.

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Thank you,

Baabak Ashuri, Professor, Georgia Tech
Mohsen Shahandashti, Associate Professor, University of Texas at Arlington (UTA)

Page Break

Q156 *

What best describes your primary background?

- ◯ Owner agency employee (i.e., Department of Transportation staff)
- ◯ Owner adviser (or Owner Rep.)
- ◯ Design consultant
- ◯ Specialty sub-consultant
- ◯ General contractor
- ◯ Specialty contractor
- ◯ Developer
- ◯ Construction engineering and inspection (CEI) specialist
- ◯ Other (please specify)

Q157

What is your current role or job title?

Q158

In what state(s) do you have the most experience in this role? (select all that apply)

- ☐ Alabama
- ☐ Alaska
- ☐ Arizona
- ☐ Arkansas
- ☐ California
- ☐ Colorado
- ☐ Connecticut
- ☐ Delaware
- ☐ District of Columbia
- ☐ Florida
- ☐ Georgia
- ☐ Hawaii
- ☐ Idaho
- ☐ Illinois
- ☐ Indiana
- ☐ Iowa
- ☐ Kansas
- ☐ Kentucky
- ☐ Louisiana
- ☐ Maine
- ☐ Maryland
- ☐ Massachusetts
- ☐ Michigan
- ☐ Minnesota
- ☐ Mississippi
- ☐ Missouri
- ☐ Montana
- ☐ Nebraska
- ☐ Nevada
- ☐ New Hampshire
- ☐ New Jersey
- ☐ New Mexico
- ☐ New York
- ☐ North Carolina

- ☐ North Dakota
- ☐ Ohio
- ☐ Oklahoma
- ☐ Oregon
- ☐ Pennsylvania
- ☐ Puerto Rico
- ☐ Rhode Island
- ☐ South Carolina
- ☐ South Dakota
- ☐ Tennessee
- ☐ Texas
- ☐ Utah
- ☐ Vermont
- ☐ Virginia
- ☐ Washington
- ☐ West Virginia
- ☐ Wisconsin
- ☐ Wyoming
- ☐ I do not reside in the United States

Q159 *

How many years of experience do you have in the transportation industry?

- ○ 0-5 years
- ○ 6-10 years
- ○ 11-20 years
- ○ 20+ years

Page Break

Q160

Background Information: Please read the paragraph below.

Employee benefits include medical insurance, vacation, and retirement benefits. Employee benefits help to create economic security for employees, and in doing so, improve worker retention and engagement. The data from the Center for Construction Research and Training (CPWR) show that nearly 24% of construction workers did not have any health insurance in 2018, more than double the uninsured rate among all U.S. workers. According to CDC reports published before the pandemic, construction workers suffer worse mental health conditions in general compared to any other industries: the highest rate of drug overdose fatalities and the highest suicide rate. The pandemic worsens the condition as it causes stress, fear, anxiety, and depression across the country. CDC household pulse survey in April 2020 shows that symptoms of anxiety and depression are more than triple the level of the same quarter in 2019.

Page Break

Q161

Description of a hypothetical decision-making scenario: Suppose that your organization recently set up a dedicated fund for emergency response in the wake of a pandemic. The fund aims to support initiatives with greatest potential to mitigate emerging workforce management challenges since the outbreak of pandemic. As the first step, all employees are invited to submit their ideas. Shortlisted ideas will be considered for funding support. You, as one of the invited reviewers, are about to read five submitted ideas. Afterwards, you need to give your recommendations.

Page Break

Q162

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Q163

You are given 10 points to distribute among the ideas. Make sure the sum of points you give to ideas 1-5 is equal to 10. Please grade each idea (maximum possible grade = 10)

Idea 1	0
Idea 2	0
Idea 3	0
Idea 4	0
Idea 5	0
Total	0

Page Break

Q164

Please rate your familiarity with respect to the following five fields (1 = least familiar; 5 = most familiar)

	1	2	3	4	Click to write Scale Point 5
Vocational Training and Education for Construction Workers	○	○	○	○	○
Employee Benefits and Compensation	○	○	○	○	○
Occupational Safety and Health for Construction Workers	○	○	○	○	○
Onsite Construction Project Management	○	○	○	○	○
Equity, Diversity, and Inclusion (EDI)	○	○	○	○	○

Import from library Add new question

Question Block C

Q165

CONSENT TO PARTICIPATE IN A RESEARCH STUDY
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Georgia Institute of Technology and University of Texas at Arlington

Dear Participants,

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Baabak Ashuri, Professor, Georgia Tech
Mohsen Shahandashti, Associate Professor, University of Texas at Arlington (UTA)

Page Break

Q166 *

What best describes your primary background?

- ○ Owner agency employee (i.e., Department of Transportation staff)
- ○ Owner adviser (or Owner Rep.)
- ○ Design consultant
- ○ Specialty sub-consultant
- ○ General contractor
- ○ Specialty contractor
- ○ Developer
- ○ Construction engineering and inspection (CEI) specialist
- ○ Other (please specify)

Q167

What is your current role or job title?

Q168

In what state(s) do you have the most experience in this role? (select all that apply)

- ☐ Alabama
- ☐ Alaska
- ☐ Arizona
- ☐ Arkansas
- ☐ California
- ☐ Colorado
- ☐ Connecticut
- ☐ Delaware
- ☐ District of Columbia
- ☐ Florida
- ☐ Georgia
- ☐ Hawaii
- ☐ Idaho
- ☐ Illinois
- ☐ Indiana
- ☐ Iowa
- ☐ Kansas
- ☐ Kentucky
- ☐ Louisiana
- ☐ Maine
- ☐ Maryland
- ☐ Massachusetts
- ☐ Michigan
- ☐ Minnesota
- ☐ Mississippi
- ☐ Missouri
- ☐ Montana
- ☐ Nebraska
- ☐ Nevada
- ☐ New Hampshire
- ☐ New Jersey
- ☐ New Mexico
- ☐ New York
- ☐ North Carolina

- ☐ North Dakota
- ☐ Ohio
- ☐ Oklahoma
- ☐ Oregon
- ☐ Pennsylvania
- ☐ Puerto Rico
- ☐ Rhode Island
- ☐ South Carolina
- ☐ South Dakota
- ☐ Tennessee
- ☐ Texas
- ☐ Utah
- ☐ Vermont
- ☐ Virginia
- ☐ Washington
- ☐ West Virginia
- ☐ Wisconsin
- ☐ Wyoming
- ☐ I do not reside in the United States

Q169 *

How many years of experience do you have in the transportation industry?

- ○ 0-5 years
- ○ 6-10 years
- ○ 11-20 years
- ○ 20+ years

Page Break

Q170

Background Information: Please read the paragraph below.

Construction as an “essential work” during the pandemic has been a major source of outbreaks during the pandemic. The accident records released by the New York City Department of Building show that since reopening in June 2020, the monthly accident (non COVID-related) rates are higher than the pre-pandemic rates. In January 2021, the University of California, San Francisco researchers found out that the mortality rate of Californian construction workers during the COVID-19 pandemic is 27% higher than historical periods. According to a survey by the Center for Construction Research and Training (CPWR) in July 2021, the vaccine hesitancy in the construction industry is considerably higher than that of all other occupations: 38.9% vs. 15.6%.

Page Break

Q171

Description of a hypothetical decision-making scenario: Suppose that your organization recently set up a dedicated fund for emergency response in the wake of a pandemic. The fund aims to support initiatives with greatest potential to mitigate emerging workforce management challenges since the outbreak of pandemic. As the first step, all employees are invited to submit their ideas. Shortlisted ideas will be considered for funding support. You, as one of the invited reviewers, are about to read five submitted ideas. Afterwards, you need to give your recommendations.

Page Break

Q172

Please review the following proposal ideas:

"**Idea 1:** Set up a dedicated taskforce to review and update employee paid sick leave policy and family leave wages, with consideration of the impacts of COVID-19. Include appropriate health insurance as part of employee benefits package. Educate employees on their rights and protections associated with mental health. Provide necessary counselling services. Review employee payment and make necessary changes to ensure its attractiveness to construction workers.

Idea 2: Enhance existing workforce training to accommodate the new normal after COVID-19, such as strengthening training related to prefabrication, modular construction, construction automation, and digitalization of documents. Transform existing apprenticeship curriculums to ensure health and safety of the participants, while complying with the educational standards, for example, designing take-home kits or turning group projects into individual projects.

Idea 3: Evolve existing safety training and induction to overcome the widespread "vaccine hesitancy". COVID-related safety factors are important and must be continued. But there are several other health and safety issues in the construction job site that should not be overlooked. Heighten awareness of critical safety issues, such as falls and slips, by ensuring necessary time in daily induction, using obvious visual aids for spacing location, walkway, and scaffold.

Idea 4: Enhance existing planning and scheduling to increase productivity and mitigate the impacts of the pandemic, as well as associated supply chain disorder, on schedule. Streamline construction sites: more space, less overlap of trades, less double handing of materials, and fewer “hanging around” people. Introduce flexible shifts to maximize the use of equipment and involve more workers while avoiding large crowds congregating.

Idea 5: Provide dedicated training on diversity, equity, and inclusion, with focus on jobsite. Set up a safe environment to let workers report racist actions. Have a system to track incidents, and make firm disciplinary actions against the violators. Ensure various resources including professional training are equally reached to minority workers."

Q173

You are given 10 points to distribute among the ideas. Make sure the sum of points you give to ideas 1-5 is equal to 10. Please grade each idea (maximum possible grade = 10)

Idea 1	0
Idea 2	0
Idea 3	0
Idea 4	0
Idea 5	0
Total	0

Page Break

Q174

Please rate your familiarity with respect to the following five fields (1 = least familiar; 5 = most familiar)

	1	2	3	Click to write Scale Point 4	Click to write Scale Point 5
Vocational Training and Education for Construction Workers	○	○	○	○	○
Employee Benefits and Compensation	○	○	○	○	○
Occupational Safety and Health for Construction Workers	○	○	○	○	○
Onsite Construction Project Management	○	○	○	○	○
Equity, Diversity, and Inclusion (EDI)	○	○	○	○	○

Import from library Add new question

Add Block

End of Survey

We thank you for your time spent taking this survey.

Your response has been recorded.

REFERENCES

[1] H. R. Thomas and M. J. Horman, "Fundamental principles of workforce management," *Journal of Construction Engineering and Management*, vol. 132, no. 1, pp. 97–104, 2006.

[2] D. Jato-Espino, E. Castillo-Lopez, J. Rodriguez-Hernandez, and J. C. Canteras-Jordana, "A review of application of multi-criteria decision making methods in construction," *Automation in construction*, vol. 45, pp. 151–162, 2014.

[3] P. Z. Razi, M. I. Ali, and N. I. Ramli, "Overview of analytical hierarchy process decision making method for construction risk management," *IOP Conference Series: Earth and Environmental Science*, vol. 244, no. 1, p. 012 034, 2019.

[4] P. F. Buller and G. M. McEvoy, "Strategy, human resource management and performance: Sharpening line of sight," *Human Resource Management Review*, vol. 22, no. 1, pp. 43–56, 2012.

[5] S. Durdyev and J. Mbachu, "On-site labour productivity of new zealand construction industry: Key constraints and improvement measures," *The Australasian Journal of Construction Economics and Building*, vol. 11, no. 3, pp. 18–33, 2011, doi:10.3316/informit.420783685347817.

[6] J. C. Fiolet, C. Haas, and K. Hipel, "Risk-chasing behaviour in on-site construction decisions," *Construction Management and Economics*, vol. 34, no. 12, pp. 845–858, 2016, doi:10.1080/01446193.2016.1207790.

[7] A. of America, "2023 workforce survey analysis," Associated General Contractors of America, Tech. Rep. 3, 2023, https://www.agc.org/sites/default/files/users/user21902/2023%20Workforce%20Survey%20Analysis%20(3).pdf, pp. 1–18.

[8] A. N. Releases, "Abc: 2024 construction workforce shortage tops half a million," Associated Builders and Contractors, Tech. Rep., Jan. 2024, https://www.abc.org/News-Media/News-Releases/abc-2024-construction-workforce-shortage-tops-half-a-million.

[9] O. A. Ayodele, A. Chang-Richards, and V. González, "Factors affecting workforce turnover in the construction sector: A systematic review," *Journal of Construction Engineering and Management*, vol. 146, no. 2, p. 03 119 010, 2020, doi:10.1061/(ASCE)CO.1943-7862.0001747.

[10] M. C. G. Davidson, N. Timo, and Y. Wang, "How much does labour turnover cost? a case study of australian four- and five-star hotels," *International Jour-*

nal of Contemporary Hospitality Management, vol. 22, no. 4, pp. 451–466, 2010, doi:10.1108/09596111011042686.

[11] C. Martin, "Explaining labour turnover: Empirical evidence from uk establishments," *Labour*, vol. 17, no. 3, pp. 391–412, 2003, doi:10.1111/1467-9914.00246.

[12] J. R. Wilkins, "Construction workers' perceptions of health and safety training programmes," *Construction Management and Economics*, vol. 29, no. 10, pp. 1017–1026, 2011, doi:10.1080/01446193.2011.633538.

[13] M. Gupta, A. Hasan, A. K. Jain, and K. N. Jha, "Site amenities and workers' welfare factors affecting workforce productivity in indian construction projects," *Journal of Construction Engineering and Management*, vol. 144, no. 11, p. 04 018 101, 2018, doi:10.1061/(ASCE)CO.1943-7862.0001574.

[14] N. Niroshana, C. Siriwardana, and R. Jayasekara, "The impact of covid-19 on the construction industry and lessons learned: A case of sri lanka," *International Journal of Construction Management*, vol. 23, no. 15, pp. 2521–2538, 2022, doi:10.1080/15623599.2022.2076016.

[15] A. D. Morantz, "Has devolution injured american workers? state and federal enforcement of construction safety," *The Journal of Law, Economics, & Organization*, vol. 25, no. 1, pp. 183–210, 2009, doi:10.1093/jleo/ewn017.

[16] N. V. Schwatka, L. M. Butler, and J. R. Rosecrance, "An aging workforce and injury in the construction industry," *Epidemiologic reviews*, vol. 34, no. 1, pp. 156–167, 2012, doi:10.1093/epirev/mxr020.

[17] C. Gallagher, M. Rimmer, and E. Underhill, "Occupational health and safety management systems: A review of their effectiveness in securing healthy and safe workplaces," *National Occupational Health and Safety Commission*, 2001, https://www.safeworkaustralia.gov.au/system/files/documents/1702/ohs_management_systems_review_effectiveness_2001_pdf.pdf.

[18] K. Frick and J. Wren, "Reviewing occupational health and safety management: Multiple roots, diverse perspectives and ambiguous outcomes," *Systematic occupational health and safety management: Perspectives on an international development*, pp. 17–42, 2000.

[19] H. Lingard, "Occupational health and safety in the construction industry," *Construction management and economics*, vol. 31, no. 6, pp. 505–514, 2013, doi:10.1080/01446193.2013.816169.

[20] S. Barnard, A. Powell, B. Bagilhole, and A. Dainty, "Researching uk women professionals in set: A critical review of current approaches," *International Journal of*

Gender, Science and Technology, vol. 2, no. 3, 2010, https://genderandset.open.ac.uk/index.php/genderandset/article/view/132.

[21] A. Powell and K. J. Sang, "Equality, diversity and inclusion in the construction industry," *Construction Management and Economics*, vol. 31, no. 8, pp. 795–801, 2013, doi:10.1080/01446193.2013.800750.

[22] D. Kahneman, *Thinking, Fast and Slow*. Macmillan, 2011, https://books.google.com/books?hl=en&lr=&id=SHvzzuCnuv8C.

[23] H. A. Simon, "Bounded rationality," *Utility and probability*, pp. 15–18, 1990, https://link.springer.com/chapter/10.1007/978-1-349-20568-4_3.

[24] G. Gigerenzer and R. Selten, *Bounded Rationality: The Adaptive Toolbox*. MIT Press, 2002, https://books.google.com/books?hl=zh-TW&lr=&id=s73eYl1DRHUC.

[25] A. S. Luchins, "Mechanization in problem solving: The effect of einstellung," *Psychological Monographs*, vol. 54, no. 6, p. i, 1942, doi:10.1037/h0093502.

[26] T. Gilovich, R. Vallone, and A. Tversky, "The hot hand in basketball: On the misperception of random sequences," *Cognitive Psychology*, vol. 17, no. 3, pp. 295–314, 1985, doi:10.1016/0010-0285(85)90010-6.

[27] Y. Liang, A. Baral, M. Shahandashti, and B. Ashuri, "Availability heuristic in construction workforce decision-making amid covid-19 pandemic: Empirical evidence and mitigation strategy," *Journal of Management in Engineering*, vol. 38, no. 5, p. 04 022 046, 2022.

[28] A. Tversky and D. Kahneman, "Availability: A heuristic for judging frequency and probability," *Cognitive Psychology*, vol. 5, no. 2, pp. 207–232, 1973, doi:10.1016/0010-0285(73)90033-9.

[29] C. MacLeod and L. Campbell, "Memory accessibility and probability judgments: An experimental evaluation of the availability heuristic," *Journal of Personality and Social Psychology*, vol. 63, no. 6, p. 890, 1992, doi:10.1037/0022-3514.63.6.890.

[30] L. Dube-Rioux and J. E. Russo, "An availability bias in professional judgment," *Journal of Behavioral Decision Making*, vol. 1, no. 4, pp. 223–237, 1988, doi:10.1002/bdm.3960010404.

[31] J.-P. Unger, I. Morales, and P. De Paepe, "Medical heuristics and action-research: Professionalism versus science," *BMC Health Services Research*, vol. 20, pp. 1–9, 2020, doi:10.1186/s12913-020-05547-7.

[32] H. S. M. Hasan, H. Ahamad, and M. R. Mohamed, "Skills and competency in construction project success: Learning environment and industry application-the gap," *Procedia Engineering*, vol. 20, pp. 291–297, 2011, doi:10.1016/j.proeng.2011.11.135.

[33] K. A. Batterton and K. N. Hale, "The likert scale: What it is and how to use it," *Phalanx*, vol. 50, no. 2, pp. 32–39, 2017, doi:10.22360/issn.1045-8479.2017.50.2.32.

[34] J. Kim and P. Philips, "Health insurance and worker retention in the construction industry," *Journal of Labor Research*, vol. 31, pp. 20–38, 2010, doi:10.1007/s12122-009-9074-2.

[35] S. Eaves, D. E. Gyi, and A. G. Gibb, "Building healthy construction workers: Their views on health, wellbeing and better workplace design," *Applied Ergonomics*, vol. 54, pp. 10–18, 2016, doi:10.1016/j.apergo.2015.11.003.

[36] C.-T. C. for Construction Research and Training, "The uninsured rate of construction workers," *Data Bulletin*, vol. April 2020, pp. 1–4, 2020, https://www.cpwr.com/wp-content/uploads/publications/DataBulletin-April-2020.pdf.

[37] C. Bilginsoy, "The hazards of training: Attrition and retention in construction industry apprenticeship programs," *ILR Review*, vol. 57, no. 1, pp. 54–67, 2003, doi::10.1177/001979390305700104.

[38] N. R. Foundation, "Addressing the workforce skills gap in construction and cre-related trades," *NAIOP Research Reports*, pp. 1–28, 2020, https://www.naiop.org/globalassets/research-and-publications/report/addressing-the-workforce-skills-gap-in-construction-and-cre-related-trades/researchreportaddressing-the-workforce-gap-report.pdf.

[39] M. O. MSCM, "Capacity building for sustainable workforce in the construction industry," *The Professional Constructor*, pp. 51–71, 2016.

[40] J. M. Wong, A. P. Chan, and Y. H. Chiang, "Modeling and forecasting construction labor demand: Multivariate analysis," *Journal of Construction Engineering and Management*, vol. 134, no. 9, pp. 664–672, 2008, doi:10.1061/(ASCE)0733-9364(2008)134:9(664).

[41] C. P. Sing, P. E. D. Love, and C. M. Tam, "Stock-flow model for forecasting labor supply," *Journal of Construction Engineering and Management*, vol. 138, no. 6, pp. 707–715, 2012, doi:10.1061/(ASCE)CO.1943-7862.0000483.

[42] K. Ringen, X. S. Dong, L. M. Goldenhar, and C. T. Cain, "Construction safety and health in the usa: Lessons from a decade of turmoil," *Annals of Work Exposures and Health*, vol. 62, no. Supplement_1, S25–S33, 2018, doi:10.1093/annweh/wxy007.

[43] B. A. Evanoff, D. S. Rohlman, J. R. Strickland, and A. M. Dale, "Influence of work organization and work environment on missed work, productivity, and use of pain medications among construction apprentices," *American Journal of Industrial Medicine*, vol. 63, no. 3, pp. 269–276, 2020, doi:10.1002/aj.

[44] A. M. Dale, D. S. Rohlman, L. Hayibor, and B. A. Evanoff, "Work organization factors associated with health and work outcomes among apprentice construction workers: Comparison between the residential and commercial sectors," *International Journal of Environmental Research and Public Health*, vol. 18, no. 17, p. 8899, 2021, doi:10.3390/ijerph18178899.

[45] U. B. of Labor Statistics, *National census of fatal occupational injuries in 2023*, https://www.bls.gov/news.release/archives/cfoi_12192024.pdf, Dec. 2024.

[46] A. Hasan, B. Baroudi, A. Elmualim, and R. Rameezdeen, "Factors affecting construction productivity: A 30 year systematic review," *Engineering, Construction and Architectural Management*, vol. 25, no. 7, pp. 916–937, 2018, doi:10.1108/ECAM-04-2017-0147.

[47] Y. Zhong, Z. Chen, Z. Zhou, and H. Hu, "Uncertainty analysis and resource allocation in construction project management," *Engineering Management Journal*, vol. 30, no. 4, pp. 293–305, 2018, doi:10.1080/10429247.2018.1490450.

[48] Y. Liu, S. L. Zhao, X. K. Du, and S. Q. Li, "Optimization of resource allocation in construction using genetic algorithms," vol. 6, pp. 3428–3432, 2005, doi:10.1109/ICMLC.2005.1506905.

[49] F. A. Karaa and A. Y. Nasr, "Resource management in construction," *Journal of Construction Engineering and Management*, vol. 112, no. 3, pp. 346–357, 1986, doi:10.1061/(ASCE)0733-9364(1986)112:3(346).

[50] M. Loosemore, A. Dainty, and H. Lingard, *Human Resource Management in Construction Projects: Strategic and Operational Approaches*, 1st. Routledge, 2003, doi:10.4324/9780203417881.

[51] M.
bibinitperiod Company, *The construction productivity imperative*, Accessed: 2025-04-18, 2015.

[52] M. H. Heydari, A. Shojaei, H. Naderi, and J. Iorio, "Paving the way for progress: A systematic literature review on diversity, equity, and inclusion in the aec industry," *Journal of Management in Engineering*, vol. 40, no. 3, p. 03 124 001, 2024, doi:10.1061/(ASCE)ME.1943-5479.0000922.

[53] J. O. Choi, J. S. Shane, and Y. Y. Chih, "Diversity and inclusion in the engineering-construction industry," *Journal of Management in Engineering*, vol. 40, no. 3, p. 03 124 001, 2022, doi:10.1061/(ASCE)ME.1943-5479.0001005.

[54] OSHA.com, *The future of the construction industry: Why diversity matters*, Accessed: 2025-04-18, 2022.

[55] S. Tufféry, *Data mining and statistics for decision making*. John Wiley & Sons, 2011, doi:10.1002/9781119979454.

[56] D. C. Montgomery, *Design and analysis of experiments*. John Wiley & Sons, 2017, doi:10.1002/9781119409497.

[57] D. R. Johnson and J. C. Creech, "Ordinal measures in multiple indicator models: A simulation study of categorization error," *American Sociological Review*, vol. 48, no. 3, pp. 398–407, 1983, doi:10.2307/2095234.

[58] B. Muthén and D. Kaplan, "A comparison of some methodologies for the factor analysis of non-normal likert variables," *British Journal of Mathematical and Statistical Psychology*, vol. 38, no. 2, pp. 171–189, 1985, doi:10.1111/j.2044-8317.1985.tb00832.x.

[59] B. D. Zumbo and D. W. Zimmerman, "Is the selection of statistical methods governed by level of measurement?" *Canadian Psychology/Psychologie Canadienne*, vol. 34, no. 4, p. 390, 1993, doi:10.1037/h0078865.

[60] A. B. Taylor, S. G. West, and L. S. Aiken, "Loss of power in logistic, ordinal logistic, and probit regression when an outcome variable is coarsely categorized," *Educational and Psychological Measurement*, vol. 66, no. 2, pp. 228–239, 2006, doi:10.1177/0013164405282464.

[61] L. van der Maaten and G. Hinton, "Visualizing data using t-sne," *Journal of Machine Learning Research*, vol. 9, no. 11, pp. 2579–2605, 2008, doi:10.48550/arXiv.2008.01361.

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