



Development of Assessment Tool for Workforce Sustainability

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Abstract: The work environment in construction is physically and mentally demanding. This demanding environment can place adverse risk on the construction workforce including emotional, physical, and financial challenges. To minimize such challenges, continued development and cultivation of the construction workforce is required. Continued development and cultivation can sustain the workforce and lead to both personal and business growth. The process of developing and cultivating the workforce enhances construction workforce sustainability, a measure of the social sustainability of the construction workforce. The aim of the present study is to develop a practical tool for assessing workforce sustainability in construction. A mixed-methods research approach that relied on a review of literature, semistructured interviews, and a multiround expert survey was utilized to achieve the aim of the study. The developed workforce sustainability tool includes three levels of components (attributes, indicators, and metrics) organized in a hierarchy to characterize a workforce. The use of the assessment tool yields a final aggregated score that reveals the level of sustainability of a workforce. The present study contributes to the body of knowledge by providing a means to assess and ultimately improve workforce sustainability in construction. Widespread use of the tool is expected to help the construction industry develop and nurture its workers to produce a healthy, productive, and resilient workforce. DOI: [10.1061/\(ASCE\)CO.1943-7862.0001794](https://doi.org/10.1061/(ASCE)CO.1943-7862.0001794). © 2020 American Society of Civil Engineers.

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Introduction and Background

The physical work environment and nature of construction operations can be harsh. The intensive environment leads to operational challenges and places high physical demands on workers. Examples of physical demands include lifting heavy objects, operating heavy equipment and machinery, and working in extreme weather conditions for long hours. These operational and physical stresses have impacted the construction industry and its workforce negatively, and along with other factors have led to undesired outcomes such as high turnover rates, poor safety performance, and labor shortages (Abdelhamid and Everett 2000; Hinze 2010; FMI 2017). In the past few years, the number of work-related fatal injuries in the construction industry was the highest among all US industries (BLS 2018). In 2017 alone, 971 fatalities were reported in construction (BLS 2018). The 971 fatalities account for approximately 20% of all work-related fatalities in the United States in 2017, while construction comprises only about 5% of the overall US workforce (Abdelhamid and Everett 2000). Although the 5% could change in the future due to industry growth and expansion, the number

of fatalities has been consistently high over the last 10 years (Jones 2016). The industry is taking steps to improve the safety and health of its workforce, yet continued efforts and vigilance are needed to prevent severe injuries and fatalities from occurring.

The hazardous nature of construction commonly limits interest in working in the industry, which is likely one of the reasons for the recognized labor shortage in the industry. Research has shown that among millennials (individuals born between 1982 and 2002), a large percentage of high-school students are reluctant to pursue careers related to building and construction (Escamilla and Ostadalimakhmalbaf 2016). Other studies indicate that the workforce in construction is aging (Choi 2009; Schwatka et al. 2011). According to the Center for Construction Research and Training (CPWR) Chart Book, the proportion of workers who are from 45 to 64 years old increased from 25% to 40% between 1985 and 2015, while the proportion of younger workers (under 35 years old) has noticeably decreased by roughly 50% over the same period of time (CPWR 2018).

Furthermore, education attainment in the construction industry is lower than that in all other US industries except for agriculture (CPWR 2018). A lack of education attainment affects productivity in the industry adversely, which could be one reason why the level of productivity in construction is relatively lower than in other industries such as manufacturing (Allmon et al. 2000; Rojas and Aramvarekul 2003). The aforementioned conditions—along with other factors such as long working hours—can put the construction workforce at high risk of injury and illness. For example, working for long hours influences a person's health and prosperity, and can perhaps lead to work-family conflicts (Holden and Sunindijo 2018; Pfeffer 2010), causing work-life stress and potential performance errors in the workplace (e.g., safety incidents). Construction laborers typically work 40 h or more per week in extreme environments (CPWR 2018; Hinze 2010). The high physical demand

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required for construction jobs in these extreme environments can make construction laborers vulnerable to encountering work-life conflict, fatigue, and other physical and/or emotional harm.

To minimize these issues, the level of attention to workforce support and development in the construction industry must be improved, especially for the millennial workforce. The sustainable development movement started two decades ago and is aimed, in part, at improving the conditions for the construction workforce and helping enhance workforce development in construction (OSHA 2016). Sustainable development has been defined as “the development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (WCED 1987). Sustainable development emphasizes three fundamental dimensions: environmental protection, economic viability, and social equity (Kibert 2016). The social dimension of sustainability focuses, in part, on employee wellness, health and safety, growth, prosperity, and education (Kossek et al. 2014). Sustaining employee health and safety, for example, can enhance productivity, lead to positive safety performance, reduce costs of insurance premiums, and improve job satisfaction and employee retention.

That being said, sustainable development in practice primarily focuses on the environmental and economic dimensions of sustainability associated with the design, construction, and use of facilities, with minimal attention to the social dimension of sustainability (Hinze et al. 2013). Minimal work has been conducted over the past 20 years on the social sustainability of the construction workforce. Most of the efforts related to social sustainability have focused on organizational sustainability. The motivation behind the present study is to facilitate enhancing the level of workforce development in construction organizations and maintaining such enhanced levels. Embracing and maintaining workforce development is referred to in literature as “workforce sustainability” (Kossek et al. 2014). The goal of the present study is to develop a tool for assessing the sustainability of the construction workforce. The intended tool is referred to as an assessment tool for construction workforce sustainability.

Description of Workforce Sustainability

The concept of workforce sustainability is new to most industries but especially to construction. Lippe and Lippényi (2019) stated that a workforce is sustainable when members of the workforce are productive and satisfied in their work environment. In this regard, Kossek et al. (2014) found that a sustainable workforce can be “created and nurtured via employment practices [policies and procedures] that link employee work-life balance and well-being to employment experiences over the course of employees’ working lives, enabling them to perform well over time while also thriving in their personal and family lives.” Achieving workforce sustainability includes the process of creating an environment that supports coherent, motivated, and healthy individuals who are highly skilled and competent, and then nurturing and maintaining the requisite skills and competencies regularly using multiple strategies such as training, incentives, and career development programs. Workforce sustainability is defined as “a property of a workforce that reflects the extent to which the workforce can perform its desired function over a selected period of time” (Gambatese et al. 2019). Workforce sustainability reflects the extent to which members of the workforce feel part of a nurtured, diverse, equal, safe, connected, valued, and mature community at work. A workforce may exhibit a high or low level of sustainability depending on the acquired input (e.g., education and training) or developed qualities and skills (e.g., maturity and competence). A workforce may be self-sustaining or require external inputs to maintain its presence and ability to

perform its desired function. For the purpose of this study, the workforce consists of all members of a construction-related organization who are involved, directly or indirectly, in the construction process including laborers, engineers, supervisors, and managers.

Constructing Conceptual Model of Workforce Sustainability

Prior to performing the research activities needed for this study, the authors desired to establish a conceptual model of workforce sustainability to serve as a framework for the intended assessment tool. A mixed-methods approach was then carried out to construct the workforce sustainability conceptual model. Semistructured interviews and informal discussions with industry professionals and academics in different fields of study related to workforce development were initially conducted. This process involved interviewing six experts—four industry professionals (e.g., workforce development trainers and project managers) and two academics—performing research on human science and workforce development in construction. The interviews ranged from 15 to 30 min in length. The main purpose of the interviews was to create a framework for the intended assessment tool for construction workforce sustainability. First, a description of the scope of the study and the intended use of the framework was provided. Then, the interviewees were asked to propose a framework that could work best for the proposed study. The researchers described existing frameworks and tools used for sustainability assessment that are available to construction stakeholders. The sustainability assessment frameworks and tools described primarily included the JUST label (JUST 2017), the Leadership in Energy and Environmental Design (2019), the Safety Climate Assessment Tool (Probst et al. 2019), and the Certificated B Corporation (2019). After considering and examining the available assessment tools, it was concluded that the conceptual workforce sustainability model should include three levels of components organized in a hierarchy, from the most general to the most specific, as shown in Fig. 1. These three levels of components relied, in part, on the structure of the JUST label and S-CAT. The three levels of components are attributes, indicators, and metrics, respectively. The attributes constitute qualitative descriptions of foundational qualities and characteristics contributing to construction workforce sustainability, while the metrics are specific to a certain quality or characteristic and can be used to quantify an existing level of workforce sustainability within a company or an organization. Each of the levels is briefly defined below (Gambatese et al. 2019):

Attributes: Foundational qualities and characteristics contributing to construction workforce sustainability;

Indicators: Practices, procedures, and policies that reveal the presence of each attribute within the workforce, and which can be used to assess and improve each attribute and, as a result, the overall level of workforce sustainability; and

Metrics: Measurement units and scales used to assess the extent to which the practices, procedures, and policies (i.e., indicators) are actually implemented in practice within an organization to sustain the workforce.

To identify the essential attributes of workforce sustainability, a literature review was carried out that involved reviewing both industry and academic sources. The results of the literature review provided support for eight essential attributes of workforce sustainability, illustrated in Fig. 2. The attributes are nurturing, diversity, equity, health and well-being, connectivity, value, community, and maturity. The definition of each attribute is provided in Table 1. The definitions were developed based on input from the panelists as

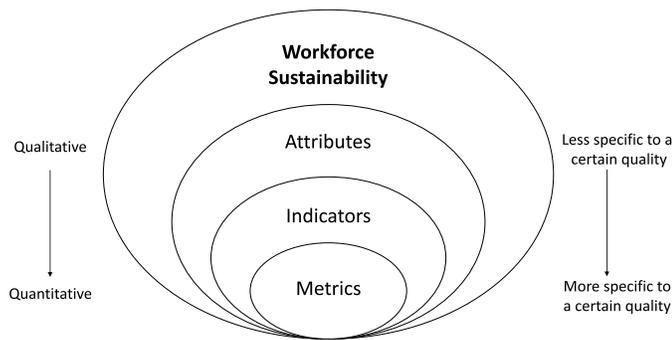


Fig. 1. Conceptual model for workforce sustainability with three levels of components.

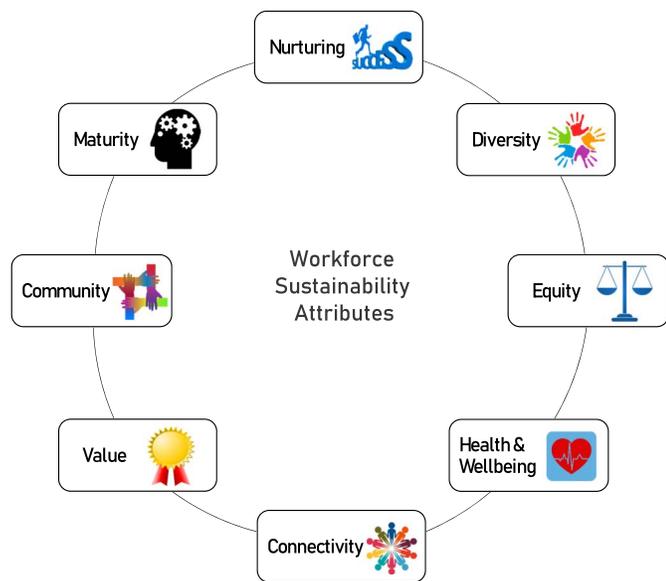


Fig. 2. Attributes of workforce sustainability. (Images courtesy of publicdomainvectors.org.)

described below. More detail about the literature review process is provided below.

The review of industry resources included examining available industry tools and publications related to workforce sustainability. The results of the review indicate that there is apparent support for the inclusion of the eight attributes. For example, the JUST label (JUST 2017), a disclosure program for organizational equity,

recognizes in its evaluation process the importance of nurturing, diversity, equity, and safety in the workplace. The International Living Future Institute—the organization that administers the JUST label—uses certain metrics to quantify each of these components. Similarly, the World Happiness Report (2017), a landmark survey to rank people’s happiness in different countries, recognizes the role employment plays in determining one’s overall happiness. According to the report, attributes such as nurturing, diversity, and equity are key determinants of employee happiness. Equally, the Gallup (2017) report titled “State of the American Workplace,” provides support for different attributes of the proposed conceptual model, namely nurturing, connectivity, value, and maturity. The Gallup report is a research-based document developed based on public opinion polls. Essentially, the Gallup report describes what workers need in order to sustain their employment. Examples of suggested practices to sustain employment include providing professional development, fair payment, and family support (Gallup 2017). Each of the aforementioned practices can be easily classified under one or more of the eight workforce sustainability attributes shown in Fig. 2 and defined in Table 1.

In the same way, academic publications and research articles on social sustainability were examined. Jafari et al. (2019) conducted a study to identify important social sustainability criteria in building energy retrofit projects. The criteria identified relate to six attributes of workforce sustainability, namely nurturing, equity, health and well-being, connectivity, value, and community. Similarly, Kossek et al. (2014), in their study about organizational strategies to achieve work-life balance and foster workforce sustainability, provided support for inclusion of most of the attributes listed in Table 1. Some of the identified strategies included providing opportunities for professional development, increasing employee wages and benefits, and encouraging knowledge sharing among employees. In an additional example, Raheem and Ramsbottom (2016) identified fundamental attributes of social sustainability in highway construction. The identified attributes are similar to the eight workforce sustainability attributes described in Table 1. The discussed literature review is summarized in Table 2. For brevity, the literature review reported in this paper is limited to six sources. Detailed information about the literature review conducted to construct the conceptual model will be discussed in a separate publication. The information reported in this paper in that regard is intended to provide a general idea of the basis for the conceptual model prior to using it to develop the workforce sustainability assessment tool.

Research Objectives and Methodology

As stated previously, the goal of this study is to develop an assessment tool for workforce sustainability. The research questions are

Table 1. Definition of workforce sustainability attributes

Attribute	Definition
Nurturing	The extent to which employees feel supported, educated, and trained in their work
Diversity	The extent to which the workforce is diversified, and members of the workforce feel welcome and accepted
Equity	The extent to which employees feel that they are treated and evaluated fairly without any discrimination
Health and well-being	The level of health, safety, and contentment that employees feel and experience in their work
Connectivity	The degree to which employees feel connected to peers, fellow employees, and management through open channels and two-way communication
Value	The extent to which employees feel respected and appreciated by peers and by their employer for their work performance, contributions, and loyalty
Community	The extent to which employees feel camaraderie and see themselves as part of a supportive and productive team
Maturity	The extent to which members of the workforce are competent, responsible toward each other, and share accountability in decision-making and problem-solving

Table 2. Identification of key workforce sustainability attributes

Source	Workforce sustainability attributes					Health and Well-being			Maturity
	Nurturing	Diversity	Equity	Connectivity	Value	Community	Value	Connectivity	
JUST (2017)	X (education)	X	X	X	X (employee benefits)	—	—	—	—
World Happiness Report (2017)	X	X	X	X (sharing)	—	X	—	—	—
Gallup (2017)	X	—	—	X (employee engagement)	X	—	—	—	X (employee performance)
Kossek et al. (2014)	X	X	—	X	X (wage and benefits)	X	X	X	X (knowledge sharing)
Raheem and Ramsbottom (2016)	X (awareness)	X	X	—	X	X	X	X	X (leadership and responsibility)
Jafari et al. (2019)	X	—	X	X	X	X	X	X	—

the following: (1) what are the important attributes of workforce sustainability and what are their levels of influence on achieving workforce sustainability, and (2) what are the indicators and metrics that can be used to assess each of the identified workforce sustainability attributes? To attain the study goal and answer the research questions, three objectives were identified as follow:

1. Quantify and verify the levels of influence of the identified workforce sustainability attributes shown in Fig. 2;
2. Identify and quantify potential indicators of each workforce sustainability attribute; and
3. Identify metrics to assess the extent to which indicators are actually implemented in practice within an organization.

Once these objectives are achieved and the questions are answered, the information necessary to create a practical tool for assessing workforce sustainability will have been developed. The intended tool will include an evaluation procedure to assess workforce sustainability in construction. The evaluation could be performed at the team, division, company, or industry levels.

To achieve the objectives of the study described in the previous section, the authors elected to rely on a multi-round subject matter expert survey using the Delphi process. Detailed information about how the subject matter experts were selected and how the survey was developed and disseminated as part of the Delphi process is provided below. The Delphi process is an interactive, structured, data-collection protocol used to obtain insights from a group of experts on specific subject matter. The group of experts plays a substantial role in the Delphi process; therefore, the selection of its members is paramount to the success of the process (Hallowell and Gambatese 2010; Sierra et al. 2015; Yeung et al. 2009). Numerous research studies in construction have relied on the Delphi technique as a reliable research method (Chan et al. 2001; Gunhan and Arditi 2005; Jafari et al. 2019; Leon et al. 2017; Yeung et al. 2009).

As part of a Delphi study, a panel of qualified experts is selected. For the present study, the expert panelists were different than the interviewees mentioned above and, once the panel was selected, the panel was asked to identify, verify, and quantify the three levels of components of workforce sustainability (attributes, indicators, and metrics) using the conceptual model of workforce sustainability described above. Feedback from the panel in the multi-round Delphi process will be utilized to develop the intended assessment tool. The three primary tasks of this research along with the methods used and outputs obtained are illustrated in Fig. 3. The selection and qualification of expert panelists as well as the Delphi process will be described subsequently.

Expert Panel Selection

In any survey, the level of expertise of the participants is paramount to the usefulness of, and confidence in, the collected responses. To ensure that the Delphi panel possesses practical and scientific perspectives, participants from both industry and academia were considered for participation on the panel. The inclusion of both industry professionals and academics provides assurance that the study findings have practical and theoretical implication. Moreover, the research team desired to employ experts from different fields of study to minimize potential biases toward one or more of the attributes.

To identify and select qualified experts, a two-step process was carried out. In the first step, potential experts were selected based on their education, experience, position, publication, and/or prior work related to workforce sustainability. In the second step, a quantitative evaluation of the selected experts based on predetermined criteria was carried out similar to previous research in construction

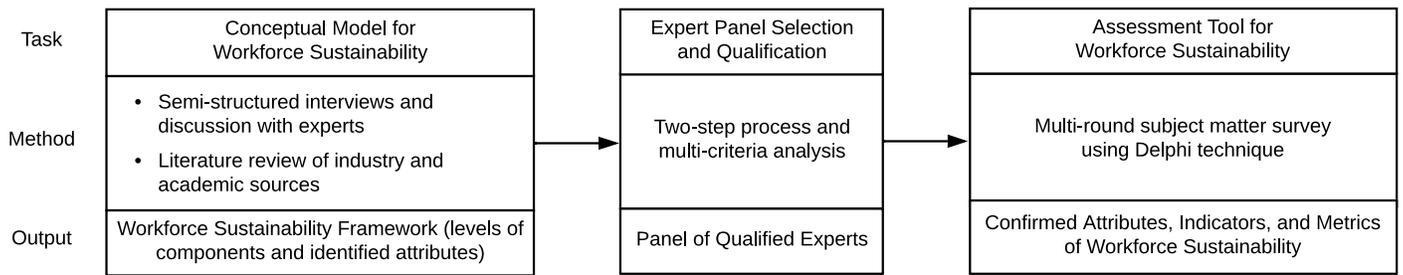


Fig. 3. Research tasks, methods, and outputs.

(Jafari et al. 2019; Hallowell and Gambatese 2010; Leon et al. 2017). Following this two-step process, potential industry experts were selected based on their position and experience within their organizations, and whether they had played a direct role in workforce development and human resource management. In a similar manner, the selection of potential experts from academia relied on authorship of research articles related to workforce development. After this initial selection process, 67 potential experts (22 academics and 45 industry professionals) were identified from online publications and resources along with the personal contact lists of the researchers. Academics were selected based on authorship of publications related to workforce development and social sustainability, while industry professionals were identified based on the connections of the researchers with industry partners. It should be acknowledged that the reliance on personal connections of the researchers with industry partners in the process of recruiting participants to this study can present a selection bias (i.e., the selection of individuals using a non-randomization sampling approach). However, such a bias is minimized by utilizing specific predetermined criteria from existing literature for identifying qualified experts in construction as described below. Only individuals located in the United States were considered for potential inclusion in the expert panel. The authors contacted and invited the potential experts, via telephone and/or email, to participate in the study. Nineteen potential experts, from both industry and academic institutions, positively responded indicating their willingness to participate in the study. However, only 16 experts (11 from industry and 5 from academia) eventually provided the requested information and participated in the initial survey round.

The second step of the selection process relied on previous research that attempted to quantify the level of expertise and knowledge of the panelists. For construction research, Hallowell and Gambatese (2010) identified predetermined criteria that can be used to qualify whether a participant is an expert in a particular field of study. The same or similar criteria have been suggested and used in different research studies in the field of construction engineering and management (Gunhan and Arditi 2005; Sourani and Sohail 2015; Yeung et al. 2009). The criteria used for the present study along with their weightings, adapted from Hallowell and Gambatese (2010), are summarized below.

- Professional registration: 3 points for each valid registration
- Years of professional experience: 1 point for every year
- Publications: Book: 4 points; journal article: 2 points; conference paper: 1 point
- Member of a committee: 3 points for each membership
- Advanced degrees: BS: 4 points; MS: 6 points; PhD: 10 points
- Leading positions: 3 points for every leading position

According to Hallowell and Gambatese (2010), a minimum score of 11 points is needed in order to confidently label a participant as an expert and include him/her in a Delphi study. The results

Table 3. Profiles and qualifications of the Delphi panel members ($n = 16$)

Expert panelists	Qualification						Total points
	A	B	C	D	E	F	
A-1	6	18	12	6	10	3	55
A-2	0	14	14	3	10	0	41
A-3	3	31	307	15	10	6	372
A-4	3	14	59	3	10	3	92
A-5	0	28	244	6	10	9	297
I-1	3	15	0	0	4	0	22
I-2	6	8	0	6	4	3	27
I-3	3	20	0	3	8	6	40
I-4	3	16	0	0	4	0	23
I-5	3	37	2	0	8	6	56
I-6	0	5	2	0	8	0	15
I-7	3	40	0	9	8	0	60
I-8	3	35	0	0	8	3	49
I-9	0	30	0	6	4	3	43
I-10	3	15	0	0	8	3	29
I-11	0	40	12	6	4	0	62

Note: A = professional registration; B = years of experience; C = publication; D = membership of committees; E = advanced degrees; and F = leading positions.

of the qualification process are presented in Table 3 for the 16 identified participants. Based on the table, it is evident that all participants received a score that is higher than 11 and were, therefore, considered qualified experts for inclusion on the Delphi panel. It should be mentioned that the number of points the panelists scored were significantly higher than the 11-point threshold. That is, all panelists except a single panelist obtained more than 20 points, with the majority of the panelists scoring 40 points or more. The high number of points scored provides high confidence that the selected panelists are experts in their field. Although there is a high variation between academics and industry professionals in terms of academic publications and practical experience, such a variation is well explained. The nature and expectations of an academic job are different from those of an industry job; hence, the variation is expected. In fact, the researchers believe the different levels of research and industry experience of the panelists is one of the strengths of the present study and its Delphi panel.

With respect to the panel size, different researchers have recommended different expert panel sizes to optimize the Delphi process. Alomari et al. (2018), Gunhan and Arditi (2005), and Jafari et al. (2019) utilized 12, 12, and 11 experts, respectively, for their Delphi studies. Based on a review of multiple Delphi studies, it was found that an expert panel of 16 members is adequate for an effective Delphi study if the panel members are carefully selected (Hallowell and Gambatese 2010; Mitchell 1991; Yeung et al. 2009).

Survey Development and Dissemination

In parallel with the expert panel selection, three questionnaires were developed by the research team. The aim of the questionnaires was to obtain feedback from the Delphi panel members regarding the content and structure of the intended assessment tool for workforce sustainability. Thereafter, the three questionnaires were distributed to the expert panelists as part of the Delphi process via email in three subsequent rounds (one questionnaire per each round).

The initial questionnaire was pilot tested with multiple experts not selected for inclusion on the Delphi panel, and suggested revisions were incorporated into the questionnaire prior to dissemination. The initial questionnaire was then distributed to the panel, and the panelists did not know the identity of the other members of the panel. At this point, the panel members completed the questionnaire before giving them the opportunity to revise and reassess their responses. In subsequent rounds, the Delphi process provides the opportunity for each panelist to revise and reassess his/her responses in light of the responses made by other members of the panel. The researchers managed the process independently and maintained confidentiality amongst the panel members. The protocol created a collaborative effort, yet ensured anonymity, providing a desired environment to develop the intended assessment tool. The output of this process is expected to capture and incorporate different perspectives about assessing workforce sustainability in construction. Variability in the participant responses is expected in the initial rounds, but consensus is commonly reached in later rounds of the Delphi process. To reiterate, the primary goal of the Delphi process was to identify, verify, and quantify workforce sustainability attributes, indicators, and metrics prior to developing a practical tool for assessing workforce sustainability. Each round of the Delphi process is described in more detail below.

Results of the Delphi Process

This section of the manuscript presents and discusses the results of the Delphi rounds. Each round will be discussed individually.

Round #1

The objective of this survey round was to verify the attributes of workforce sustainability and quantify their level of influence on workforce sustainability. The questionnaire for this round included two parts. The first part solicited information about the qualifications of the participants. The second part asked the expert panelists to evaluate the conceptual model as a framework for the development of the intended assessment tool and to indicate the level of influence that each of the eight attributes has on workforce sustainability.

Sixteen responses, one from each panelist, were received and analyzed in this round. The majority of the Delphi panel members—14 out of 16 (87.5%)—indicated that the conceptual model is a solid framework for the intended workforce sustainability assessment tool, and the eight attributes (nurturing, diversity, equity, health and well-being, connectivity, value, community, and maturity) are important

foundational qualities and characteristics to assess workforce sustainability. These 14 members—although they agreed that the conceptual model was suitable—provided suggestions to include additional qualities and characteristics in the descriptions of the attributes. For example, one participant put forward that “accountability” is an essential characteristic of a sustainable workforce and, therefore, should be included in one of the attributes. Accordingly, accountability was incorporated into the maturity attribute. Accountability in decision-making and problem-solving is a sign of maturity of a worker or a workforce.

Contrary to the majority, two members of the panel expressed concerns about the developed conceptual model for workforce sustainability. These two panelists indicated that priorities in the construction industry continually shift; therefore, it is challenging to develop a framework that corresponds to the continued shift all the time. The research team carefully examined the assessment that the two dissenting participants provided and incorporated changes into the framework to respond to such concerns. The definitions of the attributes shown in Table 1 were accordingly updated multiple times to incorporate the panelists’ feedback.

To quantify the level of influence of each attribute of workforce sustainability, the expert panelists were asked to provide a rating, based on a 5-point Likert scale. The rating scale ranged from 1 to 5 where 1 indicates low influence and 5 indicates extreme influence. Responses for this part were collected, analyzed, aggregated, and then returned back to the panelists for reassessment and confirmation in Round #2. This refinement process provided additional reliability in the findings and ensured that a high level of consensus was achieved.

Round #2

The objectives of this survey round were to: (1) reach consensus about the level of influence that each attribute has on workforce sustainability (obtained in Round #1); and (2) identify applicable indicators of each attribute that can be used to assess construction workforce sustainability.

As suggested by previous studies (Mitchell 1991; Hallowell and Gambatese 2010), the median value was used in this study to determine the level of influence of each attribute on workforce sustainability. The median is less likely to be influenced by outliers and, therefore, is more appropriate to measure central tendency. To measure consensus amongst the panelists, standard deviation (SD) is typically used due to its ability to quantify variation from central tendency (Gunhan and Ardit 2005; Hallowell and Gambatese 2010). The researchers established that, for the present study, consensus is reached whenever the standard deviation is below 1.64 as suggested by Rogers and Lopez (2002).

Based on this analysis protocol, the responses were collected and analyzed. Table 4 provides a summary of Round #2 responses regarding the levels of influence of the attributes. Fifteen experts participated in this round and provided responses; only one person did not complete the survey and was therefore removed from the panel in subsequent rounds. Of the 15 responding panelists, four participants (27%) updated one or more of their prior responses

Table 4. Descriptive statistics of Round #2 responses ($n = 15$)

Measure	Influence of workforce sustainability attributes (1 = low influence; 5 = extreme influence)							
	Nurturing	Diversity	Equity	Health and well-being	Connectivity	Value	Community	Maturity
Median	4.00	3.00	5.00	4.00	3.00	4.00	3.00	3.00
Mean	4.00	2.87	4.33	4.00	3.20	4.00	3.27	3.20
SD	0.53	1.25	1.05	0.85	0.94	1.07	1.03	0.94

from Round #1. As shown in Table 4, the standard deviations were below 1.64; therefore, consensus was reached for all attributes.

To achieve the second objective of this round, the panelists were asked open-ended questions to solicit input regarding applicable indicators that can be used to assess and improve certain qualities and characteristics of the workforce sustainability attributes. Indicators can take the form of practices, policies, procedures, or other means implemented by an organization or the workforce itself to sustain a high level of nurturing, diversity, equity, and so forth. Achieving high levels of nurturing, diversity, equity, etc. eventually leads to improved workforce sustainability at the team, division, company, and industry levels.

Identifying indicators for each attribute is an indispensable component of the study to ensure practical feasibility of implementation of the intended assessment tool. Applicable indicators to the health and well-being attribute, for example, can be practices, procedures, and policies that the employer provides to ensure that members of the workforce are safe and healthy. Such practices, procedures, and policies can include regular toolbox meetings, annual safety training, and periodic health check-ups. These practices, procedures, and policies are expected to help workers foster, advance, and sustain their physical and mental health and, therefore, are considered applicable indicators to assess and improve the health and well-being attribute of workforce sustainability.

After receiving and analyzing responses in Round #2, it was found that 282 indicators were suggested by the expert panel, which is too many for all to be included and create an assessment tool that is feasible to implement in practice. To shorten the list of indicators, similar indicators were grouped together, and the wording of some suggested indicators was modified to improve clarity and maintain consistency with industry terms. Indicators suggested by less than three experts were re-evaluated and compared with literature to determine inclusion or exclusion in the final list of indicators. That is, if the indicator is reported in literature as an important practice, policy, or procedure to assess the attribute, then the indicator was retained. Otherwise, the indicator was removed from the list of indicators. This analysis protocol led to a shorter list that included 54 indicators. It should be mentioned that while comparing with literature, the researchers also identified seven additional potential indicators not suggested by the panel. The seven indicators are company newsletter (Vecchio-Sadus and Griffiths 2004), employee happiness (JUST 2017), local community at work (JUST 2017; Valdes-Vasquez and Klotz 2012), safety policy (CSR Report 2017), union-friendly workplace (JUST 2017; Ho 2016), workload trade-off (Kossek et al. 2014), and workforce integration in industry (JUST 2017; Kossek et al. 2014; Valdes-Vasquez and Klotz 2012). These seven indicators were added to the list, producing a final list of 61 indicators (54 plus 7). This final list was then returned to the expert panelists in Round #3 for reassessment and confirmation using the same methodology used in Round #2.

Round #3

The objectives of this survey round were to: (1) finalize applicable indicators for each attribute; (2) assign a weighting that indicates the level of influence of each indicator on its applicable attribute; and (3) solicit insights from the expert panel regarding appropriate metrics to assess the identified indicators. To achieve the objectives of this round, the Delphi panel members were asked to provide two evaluations. First, the panelists were asked to provide a rating, on a 5-point Likert scale where 1 indicates low influence and 5 indicates extreme influence, of the level of influence of each indicator. Second, the researchers requested a recommendation from the

panelists on what indicators to include or exclude in the final assessment tool.

Out of the 15 panelists who participated in Round #2, 13 experts completed the survey and provided responses in Round #3. After receiving the responses, a two-step process was implemented to determine inclusion or exclusion of the suggested indicators in the assessment tool. In the first step, indicators that were suggested or supported by a clear majority of the panelists were retained. Unfortunately, there is no specific rule to determine what constitutes a clear majority. Some studies relied on a weak majority, which is defined as the agreement/disagreement of more than 50% of the participants on a particular matter, while other studies utilized the concept of infinite majority (also known as overwhelming majority) to measure agreement or disagreement (Pacuit and Salame 2006). Infinite majority occurs when an agreement or disagreement is reached by 90% or more of the participants on a particular matter. The researchers felt that both rules are extreme but in different directions. A percentage that is reasonable, rather than extreme, was needed. Accordingly, 70% (the midpoint between 50% and 90%) was selected as a threshold to determine clear majority. That is, all indicators that were suggested by or received support from 70% or more of the panelists were retained.

In the second step, the level of suggested influence for those indicators that received less than 70% consensus was examined. If the level of influence was rated as being high or extreme—4 or 5 on a 5-point Likert scale—based on the aggregated group median, the indicator was included in the final assessment tool. Otherwise, the indicator was removed from the list and excluded from inclusion in the final tool. Following this process, 19 indicators that received low consensus (less than 70%) and a low rating (3 or less) were removed or combined with similar indicators (13 indicators were removed and 6 indicators were combined), leaving a list of 42 indicators for inclusion in the assessment tool. A complete list of the indicators is provided in Appendix. The points for each indicator metric were determined based on feedback from the panelists and ranged from 3 to 5 points as mentioned above. The panelists were asked to provide a weighting that indicates the level of influence of each indicator on applicable attributes. Then, the median value was selected as the final weighting for the indicator's influence on workforce sustainability. This weighting determines whether the indicator metric will have a 3-, 4-, or 5-point hierarchy system.

Finally, in Round #3, the Delphi panel was consulted regarding the appropriate hierarchy system of each metric and how the metrics could be used to assess the extent of implementation of the workforce sustainability indicators in practice. Seven out of the 42 indicators received limited or incomplete feedback from the Delphi panel. For such cases, the authors relied on information available in literature and their personal judgment to complement the information received from the panel. Basing judgement on information available in literature improves reliability and minimizes bias in the findings. Suhr (1999) pointed out that any decision-making involves some level of subjectivity but stated that basing decision-making on relevant data (i.e., the feedback received from the Delphi panel or information available in literature) yields objective findings.

To better illustrate the idea, an example is provided. For the diversity attribute, an example is provided. For the diversity attribute, the expert panel suggested “the extent to which work crews match demographic of population in their local area” as a metric to assess “ethnic and racial diversity.” However, the expert panel did not specify limits or levels to quantify this indicator of diversity. In this case, the JUST label (JUST 2017), a disclosure program for socially just and equitable organizations, was used as a reference available in literature to describe the metric levels

Table 5. Indicator metric for ethnic and racial diversity

Levels	Measurement unit: Ethnic and racial diversity attainment within organization
1 point	Organization has a workforce with more than 25% deviation from current census data on aggregated Caucasian and non-Caucasian ethnicity and racial demographics within each organizational unit.
2 points	Organization emphasizes the importance of ethnic and racial diversity in hiring and promotion within, and has a workforce with a maximum of 25% deviation from current census data on aggregated Caucasian and non-Caucasian ethnicity and racial demographics within each organizational unit.
3 points	Organization emphasizes the importance of ethnic and racial diversity in hiring and promotion, and has a workforce with a maximum of 10% deviation from current census data on aggregated Caucasian and non-Caucasian ethnicity and racial demographics within each organizational unit.

for this indicator. That is, based on the JUST label, the percentage of deviation from current census data in the local area on aggregated Caucasian and non-Caucasian ethnicity and racial demographics was used to quantify the extent to which ethnic and racial diversity is implemented in a construction organization. Combining this metric with the median weighting received from the expert panel, a 3-point hierarchy system was created as shown in Table 5. According to the hierarchy system, an organization using the workforce sustainability tool will receive the lowest score for the “ethnic and racial diversity” indicator if the organization has a workforce with more than 25% deviation from current census data in the local area on Caucasian and non-Caucasian ethnicity and racial demographics. Contrariwise, an organization will receive higher scores for this indicator if the deviation from current census data is within 25% or less. It should be mentioned that current census data regarding ethnicity and racial demographics can be community-, region-, or state-related.

Development of Assessment Tool for Workforce Sustainability

Based on the Delphi process, the three levels of components of workforce sustainability (attributes, indicators, and metrics) were finalized. The researchers used the conceptual model shown in Fig. 1 and the results from the Delphi process to develop a practical assessment tool for construction workforce sustainability. The developed workforce sustainability tool includes eight attributes (shown in Fig. 1), 42 indicators (shown in the Appendix), and one metric for each indicator. The metrics are used to quantitatively evaluate the indicators, and the quantities obtained for the indicators are in turn used to evaluate the attributes. This bottom-up approach eventually provides an individual score for each attribute and an overall score representing the level of workforce sustainability. The workforce sustainability assessment tool can be viewed in Appendix III of the final research report titled, “Development of a Workforce Sustainability Model for Construction” (Gambatese et al. 2019). Two examples are provided below to describe the process of evaluating the indicators of workforce sustainability using the assessment tool.

Example 1—Annual Physical/Medical Check-Up

An annual physical check-up is one of the five indicators suggested by the Delphi expert panel in the present study to evaluate the “health and well-being” attribute of workforce sustainability. The results from the Delphi process revealed that this indicator can help assess the level of health, safety, and contentment that workers feel and experience in their work environment. An annual physical check-up is a preventive measure to reduce the risk of physical and emotional health problems. Organizations providing annual health check-ups for their employees can gain several benefits such as enhanced employee morale, reduced employee absenteeism, improved productivity, and lower risk of undesirable behaviors resulting from physical and emotional health problems (e.g., stress, fatigue, and emotional exhaustion). The availability of and participation in an annual physical check-up program is used as the metric for this indicator. An organization can earn from 1 to 4 points for this indicator depending on the availability of the program and level of employee participation in the program. Table 6 explains the metric for this indicator and its four levels.

Example 2—Work-Life/Family Balance

Work-life/family balance is one of the eight indicators of the value attribute of workforce sustainability. This term is used to describe the balance employees need between time allocated for work and for personal life in order to stay healthy and productive while leaving time for family and personal interests. Friendly workplaces that provide a work-life/family balance, from both policy and practice perspectives, lead to improved employee satisfaction, lower turnover rates, higher productivity, and other positive outcomes (Holden and Sunindijo 2018; Lingard et al. 2010; JUST 2017). According to the Delphi expert panel, work-life/family balance can help assess the extent to which workers are valued, respected, and appreciated in their work environment by their employer. The metric suggested to assess this indicator consists of four levels organized in a hierarchy for a total of four possible points. The indicator is assessed according to whether there are policies and practices in place to ensure work-life/family balance in the workplace and, if so, the extent of these policies and practices. In this regard, the JUST label (JUST 2017) suggested the use of employment-protected

Table 6. Indicator metric for annual physical check-up

Levels	Measurement unit: Availability of and participation in annual physical check-up program
1 point	Organization does not provide annual physical/medical check-ups for its employees.
2 points	Organization provides annual physical/medical check-ups for all full-time employees at no cost.
3 points	Organization provides annual physical/medical check-ups for all full-time employees at no cost, and more than 50% of the employees have had a physical/medical check-up in the preceding calendar year.
4 points	Organization provides annual physical/medical check-ups for all full-time employees at no cost, and more than 75% of the employees have had a physical/medical check-up in the preceding calendar year.

Table 7. Indicator metric for work-life/family balance

Levels	Measurement unit: Policies and practices in place to ensure work-life/family balance
1 point	Organization does not provide a minimum of 12 weeks of employment-protected maternity leave, a minimum of 2 weeks of employment-protected paternity leave, and a minimum of 10 weeks of employment-protected parental leave.
2 points	Organization provides a minimum of 12 weeks of employment-protected maternity leave, a minimum of 2 weeks of employment-protected paternity leave, and a minimum of 10 weeks of employment-protected parental leave.
3 points	Organization provides a minimum of 12 weeks of paid maternity leave, a minimum of 3 weeks of employment-protected paternity leave, and a minimum of 12 weeks of employment-protected parental leave.
4 points	Organization provides a minimum of 24 weeks of paid maternity leave, a minimum of 4 weeks of employment-protected paternity leave, and a minimum of 12 weeks of employment-protected parental leave.

Table 8. Description of workforce sustainability levels

Level	Score	Status	Required action
High	Above 21	Desirable practices, procedures, and policies for sustaining the workforce	Monitor and adjust as needed
Intermediate	13–21	Acceptable practices, procedures, and policies for sustaining the workforce	Monitor and improve some or all attributes
Low	Below 13	Insufficient practices, procedures, and policies in place to sustain a productive workforce	Corrective actions to improve some or all attributes

maternity, paternity, and parental leaves to measure the extent to which a workplace or an organization is family-friendly. These measures from the JUST label were adopted for this study and incorporated into the workforce sustainability assessment tool accordingly. Table 7 illustrates the metric used for this indicator along with its four possible levels. According to this metric, a workplace or an organization can score up to 4 points for this indicator.

Workforce Sustainability Score

Based on the structure of the developed tool, the maximum possible score is 29. This score was calculated by summing the median values (maximum possible weighted scores) of the eight workforce sustainability attributes shown in Table 4. A score of 29 represents the highest workforce sustainability score that can be attained according to the developed tool. This highest workforce sustainability score can be achieved if an organization implements all of the identified practices, procedures and policies (i.e., indicators) to their complete extent. However, recognizing that complete implementation may not always be possible, three workforce sustainability levels were created as described below. Each level covers a different range of scores. The highest level was established, based in part on probability theory from statistics, as deviating up to three standard deviations (3σ) from the maximum possible score, which would still indicate a high level of workforce sustainability. Three standard deviations from the maximum possible score of 29 yields a score of 21. Hence, the high level of workforce sustainability was established for any scores greater than 21. Using the same notion, an intermediate level of workforce sustainability was determined to be the range of values falling anywhere between three and six standard deviations (3σ – 6σ) away from the maximum possible score. This score was determined to be from 13 to 21, inclusive. Lastly, the level of workforce sustainability was considered low if the final score is more than six standard deviations (6σ) away from the maximum possible score—that is, any score less than 13. For each level, different actions are required to maintain and improve the construction workforce. The scores and required actions for each level are summarized in Table 8.

Conclusions and Recommendations

Workforce sustainability is the property that reflects the extent to which members of the workforce can perform their desired

function over a period of time. Sustaining the workforce requires continued workforce development and cultivation. The continued development and cultivation process includes facilitating an environment that supports coherent, motivated, and healthy individuals who are highly skilled and competent, and then nurturing and maintaining the requisite skills and competencies regularly. This research was intended to develop a practical tool for assessing and improving workforce sustainability in construction. To this end, a mixed-methods research approach was used. First, a conceptual model that served as a framework for the intended assessment tool was constructed using a combination of semi-structured interviews and discussions with experts in different fields of study. The conceptual model included three levels of components (attributes, indicators, and metrics) to characterize a workforce and assess its level of sustainability. Next, a review of literature was performed to identify key attributes of workforce sustainability. After that, a subject matter expert panel consisting of 16 panelists was utilized using a multiround survey to identify, verify, and quantify the attributes, indicators, and metrics of workforce sustainability. Eventually, a practical tool for assessing, and ultimately improving, workforce sustainability was developed.

The developed assessment tool focuses on the workforce (i.e., employees), not the organization, and, therefore, could be used by any type of organization to assess and/or improve workforce sustainability. It consists of 8 attributes, 42 indicators, and 1 metric for each indicator as well as an evaluation procedure to assess workforce sustainability in construction. The attributes focus on assessing and enhancing foundational qualities and characteristics of the workforce that sustain productive and long-term workforce employment. Such qualities and characteristics include, but are not limited to, teamwork, multiskilling, competence, responsibility, and accountability. These foundational qualities and characteristics can be enhanced in specific manners through implementing certain practices, policies, and procedures as described previously regardless of the type of employer—whether a general contractor or a specialty trade contractor, residential or commercial contractor, etc. The assessment process outlined in the present paper yields a final aggregated score that describes the level of sustainability within a workforce. The score is calculated based on the aggregated values and weights of the attributes, indicators, and metrics. The possible scores range from 7.5 to 29. A score greater than 21 indicates a high level of sustainability, a score between 13 and 21 indicates an intermediate level of sustainability, and a

score lower than 13 indicates a low level of sustainability. For each level, different actions are required to maintain and improve the sustainability of the workforce.

The development of the workforce sustainability assessment tool is expected to be the foundation for subsequent and future workforce development studies in the field of construction engineering as this tool is the first of its kind to identify and assess workforce sustainability attributes, indicators, and metrics. It should be noted that the application, implementation, and validation of the developed workforce sustainability assessment tool is beyond the scope of this study. Future studies are needed to apply,

assess, and validate the developed tool within construction projects and organizations. Such a validation study would confirm the accuracy and utility of the tool, and identify potential areas for improvement in the tool. In addition, a supporting study is needed to examine the correlation between the level of workforce sustainability and key performance indicators, such as work quality, safety performance, and worker productivity. It is expected that such an additional study would help to justify the importance of workforce sustainability and generate interest in, and diffusion of, the workforce sustainability assessment tool in the construction industry.

Appendix. Final List of Workforce Sustainability Indicators

Attribute	Indicator	Attribute	Indicator	Attribute	Indicator
Nurturing	1. Productive performance appraisals	Health and well-being	1. Safety policy and zero injury goal	Value	1. Full-time employment and long-term commitment policy
	2. Professional development and continuing education		2. Safety and health program		2. Health insurance and retirement plan
	3. Onboarding process		3. Safety toolbox and training		3. Family resources
	4. Technical skill training		4. Breaks and social interactions during workdays		4. Work-life/family balance
Diversity	1. Corporate policy on diversity and inclusion	Connectivity	5. Annual physical and medical check-up	Maturity	5. Job stability and retention
	2. Ethnic and racial diversity		1. Worker involvement in decision-making		6. Employee benefit program
	3. Gender diversity and inclusion at labor force level		2. Regular meetings with supervisor (one-on-ones)		7. Performance feedback and appreciation
	4. Gender/ethnic diversity in leadership/management		3. Employee stock ownership plan/program (ESOP)		8. Fair compensation
	5. Knowledge and skill diversity		4. Social pleasure and connecting activities during workdays		1. Leadership and communication skills
Equity	1. Equality, social justice, and nondiscrimination	Community	5. Teamwork approach within organization		2. Accountability (set performance standards)
	2. Pay structure transparency		1. Company social events		3. Competence-based education
	3. Equitable pay/compensation within organization		2. Workforce integration in industry		4. Competence-based training
	4. Equitable pay/compensation at industry level		3. Local community at work		5. Multiskilling
	5. Merit-based recruitment and promotion process/plan		4. Workload trade-off		6. Volunteering

Data Availability Statement

The data generated or used during the study are available from the corresponding author by request. Information about the *Journal's* data sharing policy can be found here: <http://ascelibrary.org/doi/10.1061/%28ASCE%29CO.1943-7862.0001263>.

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