# Defining Workforce Development: Launching a Career from CAREER

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Dr. Simmons is a former project director of the Summer Transportation Institute (STI) at South Carolina State University and Savannah River Environmental Sciences Field Station (SRESFS). Both programs were aimed at recruiting, retaining and training women and minorities in transportation, environmental science and engineering and natural resources-related fields of study. As SRESFS director, she led a board composed of 29 colleges and universities.

# Defining Workforce Development in Civil Engineering: Launching a Career from CAREER

## Abstract
This paper synthesizes the research from a CAREER award to define and offer an initial model of workforce development in civil engineering. Technological, social, and environmental changes continue to put responsibility on this profession to be responsive to the needs of communities. As the demands on civil engineering continue to evolve, the workforce needs a broader set of skills to keep pace. Undergraduate education is an important component of this training process. Although learning can happen both inside and outside the classroom, the historically technical focus of the curriculum puts additional impetus on out-of-class activities to foster professional skill development. This project, supported by a National Science Foundation (NSF) CAREER award, employed a mixed methods approach to explore out-of-class engagement of engineering students including their decisions to participate (or not), types of activities, barriers, and incentives. This research was designed to understand how co-curricular participation supports involvement, affective engagement, and learning outcomes with the ultimate aim of leveraging workforce preparation and entry.

As a general term, workforce development has been applied to a range of fields and vocations. Educators, policymakers, and practitioners have used the term in different contexts with varying conceptualizations. Workforce development covers a vast space and the need to be expansive can dilute the ability of stakeholders to make sense of the concept in sectors that have unique challenges and opportunities. This research attempts to provide a definition and preliminary model of workforce development, a focus of which is education and training, specific to the discipline to guide preparation for the next generation of civil engineers.

This paper provides an overview of the research activities and findings to demonstrate how the data have informed an understanding of workforce development that includes applications and implications for educating and training civil engineers. The paper will also detail how this understanding is guiding the career trajectory of the CAREER awardee.

## Introduction
Since this research aims to conceptualize workforce development in civil engineering, it is helpful to begin with a broader background on the topic.

### *Workforce Development*
The use of "workforce development" has burgeoned recently in academic, vocational, and political contexts leading to varying meanings of the term [1]. As examples, workforce development research has been situated in public health [2], [3], community colleges [4], [5], and K-12 teachers [6]. Across these sectors, workforce development is used to describe a range of programs and policies without consensus on a definition.

An understanding of workforce development necessitates an examination of its roots. Jacobs and Hawley [1] identified five drivers for workforce development:
1) globalization (e.g., connections between markets and different ways of international interaction), 2) technology (e.g., increases in productivity and changes in communication), 3)

new economy (e.g., free-market capitalism dictates supply and demand of goods and services), 4) political change (e.g., policies open up international investment and competition), and 5) demographic shifts (e.g., baby boomers retiring).

Based on these technological, political, economic, and social changes, Jacobs and Hawley define workforce development as “the coordination of public and private section policies and programs that provides individuals with the opportunity for a sustainable livelihood and helps organizations achieve exemplary goals, consistent with the societal context” [1, p. 12]. This definition provides a twofold need for workforce development: individual opportunity and organizational gain. Workforce development provides skills and knowledge for individuals to sustain and advance their careers while contributing to the competitiveness and productivity of their organization. However, each employment sector has unique challenges and demands that necessitate different skills and knowledge for workers within it. As a result, it is instructive to consider workforce development at a more granular scale.

*Workforce Development in Engineering*

Workforce development has long been a priority at the federal level in the United States and, more recently, has focused on science, technology, engineering, and technology (STEM). The STEM workforce helps drive technological innovation and economic competitiveness, which has far reaching policy implications including education, research, and immigration [7]. Understanding the composition of the workforce, pathways into the field, and skills required to be successful “is essential to the mutually reinforcing goals of individual and national prosperity and competitiveness” [7, p. 2]. Developing the technical workforce requires an exploration of education and training, an understanding of employer needs, examination of current undergraduate education, and definition of capable workforce [8]. One driver for preparing the workforce is the gap between skills sought by employers and the abilities that students bring into the workforce and the greatest chasm is related to professional skills such as teamwork and communication.

Although this national directive applies to the entire workforce, STEM is “composed of many different ‘sub-workforces’ based on the field of degree, occupational field, the education level required, or some combination of these factors. The demand for, supply of, and career prospects for each sub-workforce can vary significantly” [7, p.1], which necessitates a closer examination of individual sub-workforces of interest.

Within civil engineering, the accelerated rate of technological development, the declining state of national infrastructure, and the degradation of the environment present new challenges to current and future generations of workers. Civil engineers must respond to growing populations in urban areas, intensifying natural disasters, and increasing calls for sustainability [9]. Work at the intersection of human health, environmental protection, and built environment entails responsibilities that continue to broaden and these changes in practice need to be reflected in curricula. The American Society of Civil Engineers outlined the Vision for 2025 as a response to these societal shifts and its effects on the engineering profession and education [9]. Civil engineers need to develop skills in leadership, management, communication, collaboration, and creativity. These competencies will enable workers to be responsive to societal needs while also navigating the evolving landscape of the profession.

*Workforce Development Through the Undergraduate Experience*
To acquire these skills, civil engineering students need a balance of theoretical, practical, and professional knowledge [10]. This development can happen inside and outside the classroom [11]. Most engineering education research focuses on what students are formally taught in the curricular experience [12]. However, students spend less than 8% of their time per day in the classroom [13], which leaves ample opportunity for engagement outside of formal learning settings. Out-of-class engagement can be defined as curricular-related (e.g., doing homework or studying for a test), co-curricular (e.g., participating in a professional society or doing an internship), or extracurricular (e.g., participating in a sport or belonging to a social fraternity/sorority) [14]. Due to the dense technical focus of the engineering curriculum, these opportunities can foster non-technical skills that are otherwise not prioritized in the classroom. Work-based learning through co-curricular and extracurricular activities is one recommended approach for developing employability or professional skills [8]. For example, student associations and programs have been shown to effectively develop civil engineering students' leadership [14]. Since out-of-class involvement represents a potentially significant amount of time for students and the opportunity to develop skills needed in the profession, it is important to consider this context in workforce development.

One fundamental component of workforce development is fostering both quality and quantity of workers. To make sure the labor market meets demand, more students must graduate with civil engineering degrees and have the skills to be competitive in the ever-changing profession. Calls for increasing the number of engineering degree-holders are accompanied by pushes for recruiting and retaining diverse students [8], [15]. Engineering has struggled with low enrollment and high attrition of women and minorities [16]. Efforts to support persistence of underrepresented students have turned to the link between engagement and persistence [17] including via out-of-class activities [12], [18]. This research suggests the connection between involvement outside of the classroom and workforce development in terms of sustaining a diverse workforce.

**Project Summary**
This research explored the out-of-class engagement of engineering students and used a mixed methods design to advance knowledge of activities that influence involvement, affective engagement, and learning outcomes. The nexus between out-of-class engagement and workforce development is under-explored in engineering and the characterization of the former can contribute to an understanding of the latter. A brief overview of the study is provided to contextualize the research and its implications for workforce development.

*Postsecondary Student Engagement Survey (PosSES)*
The first phase of the study was the development and distribution of a survey on students' out-of-class activities and outcomes. The instrument, termed the Postsecondary Student Engagement Survey (PosSES), was generated through a process involving a literature review, Q-study with focus groups, panel of experts, and think aloud sessions. The survey was designed to understand the activities in which students participate, the barriers to participating, the incentive for participating, and the positive and negative outcomes associated with participating. The instrument also included demographic items to disaggregate responses by gender,

race/ethnicity, year in college, major, educational attainment of parent/guardian, household income, veteran status, disability, and sexual orientation. Since the research aimed to understand the effect of out-of-class engagement on the involvement and persistence of underrepresented students, these items enabled an exploration of the potentially varying experiences of different groups of students. Additional detail on the instrument can be found in [19], [20].

With 1599 respondents from STEM students (78% of which were engineering majors), PosSES provided a broad profile of out-of-class engagement that informed the succeeding qualitative phase of the project. Findings from the survey have been published [12], [18], [21].

*Student Interviews*
The interviews were designed to elicit a more nuanced understanding of students' experiences outside of the classroom. At the time of writing, this phase is ongoing. A phenomenographic approach [22] with semi-structured interviews using the critical incident technique [23], [24] is being employed to explore variation in the ways students perceive and give meaning to their out-of-class engagement.

*Intervention*
The third phase of the study is an intervention, which is ongoing in spring 2020. The intervention is a national competition calling for engineering undergraduate and graduate students to create brief videos on their experience in out-of-class activities. The videos will provide an additional source of data and a channel through which students and engineers across the United States can share their perspectives on how out-of-class activities contributed to their professional development and workforce preparation.

The project will conclude in 2020. The analysis of the collected data is ongoing and focuses on underrepresented students. Concurrently, the student interviews and intervention will be conducted. The principle investigator is beginning to reflect on how the findings from the CAREER project are linked to learning in college for underrepresented undergraduate students in engineering and the broader implications of the work on her future research. As a result, a definition of workforce development and initial model of education and training in civil engineering are presented.

**Workforce Development in Civil Engineering**
The definition and model of workforce development in civil engineering were generated through an iterative process that synthesized findings from the project and literature in other fields to situate the work of the research group in the broader context. Based on the body of work associated with the CAREER study, each of the four members of the research group (two first-year doctoral students and two postdoctoral researchers) were tasked with independently developing a definition and model of workforce development in civil engineering. During a weekly research group meeting, each member shared his or her ideas and discussed similarities and differences between their definitions and models. This discussion generated ideas to merge the concepts that were salient across all of the models and negotiate variations between them. A single definition and model were then developed and discussed the following week. Another round of conversation and iteration led to an updated version of the definition and model that are presented below.

*Definition*

> Workforce development in civil engineering is a set of interconnected programs and policies designed to provide education and training for current and future engineers to thrive in an industry with growing challenges and evolving demands. Workforce development aims to support individual capacity and organizational prosperity while bolstering national competitiveness and innovation.

Forces at the macro, or societal level, drive the needs and opportunities of the workforce. Globalization [1] is connecting the world at an unprecedented rate meaning that civil engineering projects and companies are drawing talent from around the world, which can create both competition and collaboration. As a result, civil engineers need to be globally competent and culturally aware [25]. Economic forces also dictate supply and demand in terms of the quality and quantity of workers in this industry [26]. The equilibrium of supply and demand is a moving target [27] especially as the skill needs become apparent before the lag in skill training can catch up. Accelerated technology development is one macro-level factor that contributes to civil engineers requiring agile technical skills (e.g., related to infrastructure, automation, virtual collaboration, information access, and big data). Although technical knowledge is traditionally the foundation of civil engineering education, the workforce also needs professional skills such as leadership, teamwork, ethical reasoning, disciplinary boundary crossing, and communication to be competitive and successful in the civil engineering profession [28]. With an aging workforce and high turnover [12], it is imperative to integrate these non-technical competencies in academic and professional curricula for current and future generations of engineers. In this space, it is also important to recruit and retain diverse groups to support their individual prosperity through access to low unemployment and high job stability in engineering while supporting the profession by contributing diverse viewpoints needed to address increasingly complex challenges.

*Preliminary Model*

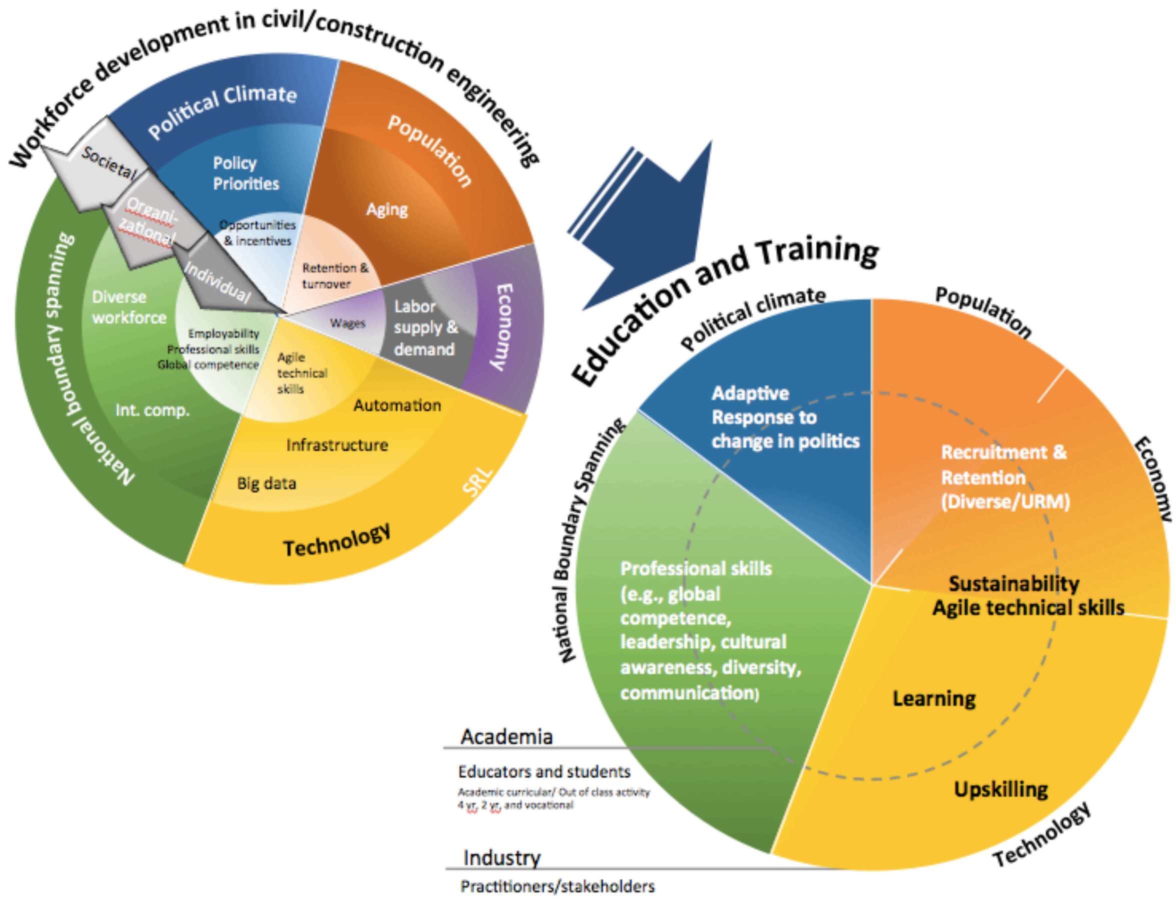


**Figure 1: Workforce development in civil engineering**

The outer ring of the circle on the left represents macro-level drivers of workforce development. These societal components were pervasive in workforce development literature across disciplines and sectors and mirror the drivers noted by Jacobs and Hawley [1]. They are included in the model since they directly relate to big-picture forces affecting civil engineering. The middle ring represents meso, or organizational, factors. These components are unique to the civil engineering industry. The inner circle encapsulates individual-level factors related to the societal and organizational rings in which they are nested. As an example, technology is driving innovation through new ways to connect people and complete tasks. In the context of civil engineering, technology has implications for infrastructure, automation, and big data (amongst many others). On an individual level, workers in civil engineering need agile technical skills to use new technology and keep pace with ever-evolving developments.

The circle on the right depicts the implications of the macro, meso, and individuals factors on education and training in civil engineering workforce development to guide the agenda of the research group. For example, to address national boundary spanning and an increasingly international civil engineering workforce, training needs to include broader professional skills such as global competence and cultural sensitivity. To address the aging workforce and persistent challenges related to recruitment, retention, and diversity, the research group is motivated to study underrepresentation in civil engineering education and practice.

**Implications, Future Directions, and Conclusion**

This research narrowed the scope of workforce development to distill what is most relevant to civil engineering. It is important to understand the definition of workforce development amidst the national conversation on preparing the engineering workforce for individual, organizational, and national achievement. Since each engineering discipline has unique cultures, responsibilities, challenges, and opportunities, this discussion is aided by examining workforce development focusing on education and training in the context of a single discipline. It is the motivation of this research to define and conceptualize workforce development to inform education and training for current and future civil engineers.

Future work in this project will continue to collect and analyze qualitative data (through the interviews and intervention). Next steps also include synthesizing across the quantitative results and qualitative findings to create a model linking out-of-class engagement for underrepresented students and workforce entry.

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