**The Civil Engineering Education Summit 2019:**
**Mapping a Future for Civil Engineering Education**

## Introduction

Over 200 civil engineering educators, practitioners, and guests convened in Dallas, Texas, in May 2019 to consider the future – our future populations, engineering challenges presented by those populations, and opportunities and challenges related to preparing civil engineers to address and meet those challenges. Participants at this *Civil Engineering Education Summit* considered visions of the future, examined current efforts by the profession and across universities to advance education in the context of those visions, and identified opportunities to transform the civil engineering educational experience to prepare students for the future. The theme for the Summit was "Empowered to Innovate," emphasizing the goal to provide the civil engineering profession with ideas, examples and encouragement to undertake the curricular innovation and other changes needed to meet the needs of our rapidly evolving profession, and highlighting the importance of building a culture of innovation within the civil engineering field. This paper provides a summary of the *findings* of the Summit and the initial efforts designed to ensure those findings help form the basis for subsequent *actions* to be undertaken by the profession and civil engineering academia.

## Defining the Vision

It has long been recognized that "engineering education" should mirror the profession itself – as a dynamic, ever-evolving field. Indeed, in its 1955 *Report on Evaluation of Engineering Education* (known as the "Grinter Report")[1], a panel sponsored by the American Society for Engineering Education (ASEE) stated:

> *"Engineering is far from static, for it is essentially a creative profession."*

This sentiment is echoed in the Summary Report of the 1995 Civil Engineering Education Conference[2]:

> *"…civil engineering education should be continually evolving to higher levels of quality and at all times incorporating new technologies and practices into the civil engineering education process."*

In keeping with these statements, the engineering profession has witnessed an acceleration of the breadth, depth, and magnitude of change – not only to the complexity of challenges engineers must address but also to the tools available to address those challenges and to the people who will address them. This accelerating pace of change necessitates revisiting our basic understanding of civil engineering education currently, and through the middle of the 21st century.

The Summit proposed a vision of civil engineering, defined at its most basic level:

***Civil Engineering is a global, holistic profession that serves the needs of all people.***

In the future-thinking focus of the Summit, it was agreed that the needs of people, and the contexts related to meeting those needs, is becoming increasingly complex in our ever-evolving world. Thus, our educational systems that prepare future engineers must also evolve to address this complexity. Thematically, the Summit captured the need for:

A **Profession** that ***serves*** people

A **Culture** that ***includes*** people

An **Education** that ***prepares*** people

## Identifying Opportunities

Defining civil engineering as a people-focused profession, participants linked people/stakeholder groups with actions addressing future needs. This exercise fostered the creation of "Opportunity Statements", in the form of:

"**(People/Group)** *need to* **(need)** *so that* **(result)**".

One example is:

*"***Students** *need to* **learn systems thinking** *so that* **they are prepared for current and future societal challenges***."*

A total of 156 Opportunity Statements were generated by Summit participants. These statements were then grouped by the identified people, the need(s), and the opportunity/result. The groupings then allowed for the identification of common themes. As a final step in this development process, Summit participants 'ranked' Opportunity Statements by priority – identifying a list of the "Top-20" statements to move forward with follow-up for possible action. These Top-20 statements are included in Appendix A. Although the participants prioritized opportunities for action, the full collection of Opportunity Statements developed at the Summit represents a rich database of ideas worthy of consideration by the profession and individual educational programs.

## Emerging Objectives

To address the people-focused themes of the Summit, four major objectives emerged from the discussions and workshop activities at the Summit. These objectives provide pathways towards achieving the overarching Summit goals.

## (1)
## Re-examination, and potentially redefine, the domain of Civil Engineering

A clear consensus among Summit participants is that the world is becoming increasingly complex – thus, the challenges faced by engineers are rapidly becoming increasingly complex. One aspect of this complexity relates to the interconnected nature of infrastructure, environmental, political, and social systems. Such interconnectedness is a major driver of the dissolution of traditional 'boundaries' which define a particular engineering discipline. Summit participants dared ask the question: *"In the context of the mid-twenty-first century, what **is** a civil engineer?"* Two elements related to this most fundamental question involve the impact of technological advancement, and the evolving role of the civil engineer in society.

ASCE's *The Vision for Civil Engineering in 2025*[4] (published in 2006) anticipates the evolutionary, holistic nature of the role of civil engineers:

> *"In 2025, civil engineers will serve as master builders, environmental stewards, innovators and integrators, managers of risk and uncertainty, and leaders in shaping public policy."*

Obviously, an undergraduate civil engineering program is not sufficient to fully prepare a graduate to be a master builder, steward, innovator, manager, and leader. This is recognized in the *Civil Engineering Body of Knowledge (3rd Ed.)*, which calls for a combination of formal education, structured mentoring, and self-directed learning to position the civil engineer for career success[3]. However, an undergraduate civil engineering curriculum provides the foundation on which to build these various skill sets.

There is virtually no dissent that the already rapid pace of technological change and advancement will continue unabated (and very possibly accelerate). In his plenary remarks at the Summit, Arup Foresight engineer/futurist Chris Leubkeman observed the megatrend *"…if it can be automated, it will be automated…"*. New tools and new computational / analysis techniques are introduced into the profession at a rate beyond which most engineering education programs can react and adapt. While this issue is not necessarily new, Summit participants struggled with the disparity between the current and anticipated pace of innovation in the profession versus that in education.

A major thematic element in the Summit related to technological advancement is the need to expand the domain of civil engineering. Two areas receiving significant attention by Summit participants included:

1. Learning new competencies related to emerging technologies that are rapidly changing civil engineering (e.g., data science, robotics, sensors, drones, and virtual reality), as well as the scripting needed to use those technologies.

2. Integrating systems thinking into civil engineering education through real-world problem solving, project-based education, and high-impact experiences such as internships, service learning, study abroad, student organizations, and competitions.

These Summit discussions give rise to a major implication for 21st-century civil engineering education: **curricular flexibility**. Indeed, "flexibility" emerged as a primary theme among Opportunity Statements related to civil engineering curricula, with five (5) of the Top 20 Opportunity Statements addressing the issue. Summit participants called for civil engineering departments to be given the the ability to define, for themselves, a program of study to meet the needs of their stakeholders within only very broad overarching guidelines. Such flexibility enables a more rapid response to technological changes in the profession; an integration of instruction addressing future roles of civil engineers; and an elevation of professional skills as a requirement in civil engineering education.

## (2)
## Elevate professional skills to a truly equal footing with technical skills

Certainly, the need for strong professional skills has long been recognized by both civil engineering educators and practitioners. The ASEE Grinter Report[1] included two outcomes related to this concept:

> *"An insistence upon the development of a high level of performance in the oral, written, and graphical communication of ideas"*
>
> *"A continuing, concentrated effort to strengthen and integrate work in the humanistic and social sciences into engineering programs"*

The Summary Report of the 1995 Civil Engineering Education Conference[2] contained numerous recommendations related to professional skills; for example:

> *"Emphasize the need for sensitivity to culturally diverse groups"*
>
> *"Encourage students to convey the importance of engineering works to non-engineering students on campus"*
>
> *"Recognize communication skills, leadership skills, management, and teamwork by creating awards for students"*
>
> *"Provide learning from non-verbal communication and listening skills"*
>
> *"Provide industry speakers to emphasize the importance of communication skills, leadership, management, and teamwork"*

The ASCE *Civil Engineering Body of Knowledge 3rd Edition* (BOK3)[3], published in 2019, also recognizes this need; it includes six outcomes related to professional skills: communication, teamwork and leadership, lifelong learning, professional attitudes, professional responsibilities, and ethical responsibilities.

It is, perhaps, not surprising that multiple generations of educators and practitioners (1955, 1995, 2019) recognized the necessity for professional skills in the successful civil engineer. The Summit participants were no different in this regard. It is curious, however, that these multiple generations were all moved to emphasize the need for increasing the level of professional skills in graduates – suggesting that the profession continues to lag in the development of these skills in our students.

It is clear that Summit participants placed significant emphasis on this topic. Of the 20 prioritized Opportunity Statements, seven (7) address professional skills and abilities. Moving forward, topics related to Professional Skills should be elevated in importance within curricula – to be thought of not as 'desirable', but 'required', on an equal basis with the various technical/design skills currently emphasized in undergraduate programs.

## (3)
## Develop a diverse, inclusive, equitable, and engaging culture within the civil engineering profession

Summit participants engaged in significant discussion regarding "professional culture" related topics in the context of civil engineering. While it may be tempting to place these topics and discussions within the realm of professional skills/attitudes, this subject rose to represent a major theme of the event. At least four (4) of the "top 20" prioritized Opportunity Statements address the concept of a civil engineering culture. Participants explored the distinct nature – yet interconnectedness – of diversity, inclusion, and equity; the necessity of engaging students at all levels; and the concept of permeating the student educational experience with these concepts. From a practical perspective, the following elements must be addressed by the entire profession, both the education and practitioner communities:

- Dedicated and intentional instruction/training related to diversity, inclusion, and equity
- Increasing representation within the profession – including student bodies, faculty ranks, and practitioners (at all levels)
- Modeling inclusivity and equity in the classroom and in the workplace
- Engaging students at all levels (K-12, college/university), and communicating the value of a civil engineering degree

**(4)**
**Foster an ongoing commitment to transformative education**

Planners for the 2019 Civil Engineering Education Summit consulted a significant body of literature to explore topics and themes arising from previous assessments of engineering education. There have been, over the years, remarkable similarities in topical areas and themes arising from these efforts. Some issues identified during an assessment continued to be issues identified in a subsequent assessment 30 to 40 years later.

Summit participants agreed that the exercise was highly worthwhile, and expressed both hope and confidence that real and significant change could result from the work accomplished during the Summit. Change will require:

- Ongoing commitment of the civil engineering community – educators and practitioners – to provide the time, effort, and resources necessary to develop, implement, and monitor actions arising from the Summit recommendations.
- A regular schedule of civil engineering education Forums, i.e. on a 3- to 4-year basis, to assess progress on initiatives from previous efforts and to address new challenges and opportunities.
- Support of academia and the profession, including ASCE for resources required to develop and implement action items relating to the priorities identified at the Summit.

**Next Steps**

In November 2019, ASCE's Committee on Education (COE) approved the creation of the Civil Engineering Education Summit Working Group (CEE-SWG), to provide leadership for follow-up activities related to the findings of the Summit. Specifically, the charge of the CEE-SWG includes:

- Disseminate Summit Report and communicate recommendations to all relevant stakeholders.
- Draft plan of short- and long-term actions:
    - Consider recommendations presented in the Summit Report
    - Consider other sources of relevant input including ASCE Strategic Goals and Future World Vision
    - Develop plan for convening future CE Education Summits.
    - Establish timeline for actions
    - Identify responsible entities for actions and resource needs.
- Solicit input on recommendations and action plan from relevant stakeholders.
- Execute short- and long-term actions as appropriate.

The CEE-SWG began its work in February 2020. In October 2020 it completed a summary report of the Summit – *Education Summit: Mapping the Future of Civil Engineering Education*.[5] The CEE-SWG then turned its attention to developing a comprehensive "action plan" for implementing the recommendations of the Summit. The draft *Civil Engineering Education Summit: Action Plan* was submitted for consideration to the ASCE Committee on Education (COE) and the ASCE Department Heads Coordinating Council (DHCC) in May 2021.

The overarching strategy adopted by the CEE-SWG in the *Action Plan* is to empower each person and organization to innovate – tapping into the creativity and unique opportunities present throughout the civil engineering community – to forge a global, holistic profession that serves the needs of all people. Innovation, then, is a key driving force in the preparation of future engineers.

Actions identified in the *Action Plan* are proposed for each of two target audiences:

(1) **Directed, Specific Actions** are linked to organizations and other entities who could sponsor and lead the specified action(s);

(2) **Grassroots Actions** include activities that should be accomplished by any/all stakeholders, on a variety of scales (local, regional, national, etc.) highlighting the opportunity – and critical importance – for all members of the profession to participate.

Collectively, actions to empower innovation in relation to the four Summit objectives seek to:

- **Spark** innovation that integrates justice, equity, diversity, and inclusion (JEDI) through initiatives across the profession;

  These actions directly address Objective 3, while also strongly supporting Objective 2. Meeting Objectives 2 and 3 will require a long-term commitment and as such, including these actions into ongoing education efforts (Objective 4) is vital.

- **Spread** innovation through engaging industry and related organizations;

  The shared nature of the task to *empower all to innovate* requires us to collaboratively consider the civil engineering domain; actions here directly address Objective 1. There are also strong ties to the culture of the profession (Objective 3), and to pursuit of these actions on an ongoing basis (Objective 4).

- **Speed** innovation through sharing knowledge and experiences;

  The best resource(s) for innovation and innovative practices in civil engineering are the members of the profession and their diverse experiences and insights. Actions to share our collective knowledge and experiences are directly tied to Objectives 1, 3, and 4, and strongly related to Objective 2.

- **Sustain** innovation through regularly scheduled conferences and workshops.

These actions directly address Objective 4. Continuous engagement will sustain and strengthen innovation in civil engineering education. Additionally, content and activities at education-related events will address Objectives 1, 2, and 3.

It is anticipated that the *Action Plan* will be formally adopted and published by ASCE in the fall of 2021. It is notable that the Action Plan calls for ASCE to establish a formal subcommittee (under the Committee on Education) whose charge would be to proactively monitor progress on implementation of actions proposed in the *Action Plan*, and to plan for each future civil engineering education Forum.

## Conclusion

Summit participants understood that 'change' does not typically occur by happenstance – it takes dedication to the vision and a willingness to work for it. To summarize this concept, participants agreed that all who are invested in the civil engineering education enterprise must seek to **TAP** our potential:

- Work with **T**enacity,
  *to ensure that needed change occurs*;
- Work with **A**udacity,
  *to propose bold actions and tactics to fully realize necessary change*;
- Work with **P**racticality,
  *understanding that necessary change can, and must, occur over different time scales*.

Collectively, the vision proposed by the Summit participants is bold and far-reaching. The Opportunity Statements identify both near-term and long-term action areas that will position the civil engineering profession for continued advancement and leadership through the mid-21st century. As such, the findings of the Summit should provide vital input to future initiatives such as revisions to the Civil Engineering Body of Knowledge (BOK), future formulations of the ABET Civil Engineering Program Criteria (CEPC), ASCE's *Future World Vision* and *Engineer Tomorrow*, and to civil engineering curricula across colleges and universities.

## References


1. "Summary of the Report on Evaluation of Engineering Education", *Journal of Engineering Education*, American Society for Engineering Education, Washington, DC, September 1955, pp. 25-60.

2. "Summary Report: 1995 Civil Engineering Education Conference (CEEC '95)". American Society of Civil Engineers, Denver, CO, June 8-11, 1995.

3. "Civil Engineering Body of Knowledge: Preparing the Future Civil Engineer", 3rd Edition, American Society of Civil Engineers, Reston, VA, 2019.

4. “The Vision for Civil Engineering in 2025”, American Society of Civil Engineers, Reston, VA, 2006.

5. Hall, K., Linzell, D., Minsker, B., Hajjar, J., and Saviz, C., “Education Summit: Mapping the Future of Civil Engineering Education”, American Society of Civil Engineers, Reston, VA, 2020. ISBN (PDF): 9780784483251

## APPENDIX A
## "Top-20" Opportunity Statements – 2019 Civil Engineering Education Summit

1. Students need to learn systems thinking so that they are prepared for current and future societal challenges.
2. Students need to develop people-focused skills so that they can design infrastructure that is relevant to society.
3. Faculty need to emphasize systems thinking so that sustainable, socially-just infrastructure can be designed.
4. Civil Engineering faculty need to integrate creativity into the curriculum to build thought leaders and innovators.
5. Faculty need to adopt evidence-based instructional methods so that students can develop critical thinking skills in order to evaluate alternative approaches of civil engineering like sustainability and equity.
6. K-12 students need to be exposed to the challenges of the future so that as future Civil Engineers they are equipped to solve them.
7. Faculty need to provide learning opportunities inside and outside the classroom so that students can build portfolios of life experiences.
8. Civil Engineering students need to exhibit the attitudes and behaviors of innovation so that they can respond to future challenges.
9. University administrators need to be adaptable and offer resources so that new curricular approaches are encouraged.
10. Faculty need to equip students to understand equity and diversity so that students can work inclusively in a global environment.
11. Under-prepared students need access to supplementary education so that they can be successful in Civil Engineering and careers.
12. Universities need to develop a culture of equity and inclusion so that we produce a more diverse future workforce.
13. Civil Engineering faculty need to develop more flexible assessment criteria so that curricula can respond to worldwide challenges and opportunities.
14. Accrediting bodies need to foster adaptive programs so that curricula can rapidly address current and future societal needs.
15. ASCE needs to provide a repository of global teaching best practices so that the rate of innovation is increased.
16. Civil Engineering departments need to better communicate the application of a C.E. BS degree so that students see its value in any career path.
17. Faculty need to identify new metrics for scholarly productivity so that promotions are awarded to those addressing society's future needs.
18. Decision makers need to remove regulatory roadblocks so that innovation can flourish.
19. Industry-university consortia need to provide startup opportunities with funding so that students can be energized ("sparkle") by an entrepreneurial pipeline.
20. Higher Ed institutions need to form consortia so that emergent topics can be team taught with virtual technology.