How Academia and Industry Can Partner to Prepare Future Civil Engineers for Success

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Introduction

It is both an exciting and challenging time to be a civil engineer. With the passage of one of the largest infrastructure investment funding packages in U.S. history and historic investments in alternative energy initiatives, civil engineers are poised to transform our society – and our world. However, the rapid pace of change in the world dictates that civil engineers understand and account for a myriad of evolving social issues (including climate change, sustainability, resiliency, and social equity), along with advances in technology that change our understanding of the problems we face, as well as the tools we use to solve them. It is not adequate for civil engineers to simply find workable engineering solutions. Society expects civil engineers to develop the best solutions, to protect and advance public health, safety, and welfare – their professional duty.

Civil engineers must have a much broader and deeper understanding of these factors than ever before, while the pace of change continues to accelerate. Undergraduate civil engineering programs are challenged to fit in all that is required in a four-year degree program. Not all employers understand the importance of further formal education, progressive mentored experience, and self-development to adequately prepare their engineers for their professional duties. Further, the use of technology to efficiently and effectively learn and work remotely – accelerated by the COVID 19 pandemic – has left lasting impacts on how both academia and industry interact with their students/employees. Combined, these factors dictate that academia and industry pivot and partner to help their civil engineers become more self-aware of their abilities and self-directed in their formal education, workplace experiences, and life-long self-development to ensure that they attain and maintain the attributes necessary to meet their professional obligations to society and the profession.

The American Society of Civil Engineers (ASCE), as the recognized leader of the civil engineering profession, monitors these factors with the goal of ensuring that civil engineers understand and stay abreast of what they need to know. One tool that ASCE uses is the Civil Engineering Body of Knowledge (*CEBOK*). Every eight years, ASCE publishes a *CEBOK* to define what civil engineers should know based on trends and advances that affect civil engineering practice. This eight-year cycle aligns with and informs ABET during their eight-year cycle of accreditation criteria review for civil engineering degree programs. The first two editions of the *CEBOK* focused primarily on influencing undergraduate educational standards for civil engineering licensure, consequently, many perceive the *CEBOK* only as an "academic exercise" that does not pertain to civil engineering practice outside formal education. With the third edition – the *CEBOK3* – this could not be further from the truth.

The third edition of *The Civil Engineering Body of Knowledge* (*CEBOK3)* [1], published in 2019, goes beyond formal education to define the complete set of knowledge, skills, and attitudes (KSAs) that all civil engineers should first attain and then maintain to serve in *responsible charge* of civil engineering services.

The *CEBOK3* should be a powerful tool to guide students, academics, early-career engineers, managers, principals, and owners as the roadmap to prepare themselves and their subordinate civil engineers for *responsible charge*. However, awareness of the *CEBOK3* is limited in academic circles and virtually non-existent outside academia (in industry). This paper will explore why the *CEBOK3* is so important to the future of civil engineering, why academia should teach the principles of the *CEBOK3* to their students, how industry can use the *CEBOK3* as a tool to train their civil engineering graduates, how ASCE can assist these efforts, and how academia and industry can partner to help civil engineering graduates seamlessly transition from undergraduate education to the rest of their career development.

Terminology

The terms *KSAs* and *responsible charge* as used in this paper, have specific meanings. *KSAs* refers to the knowledge, skills and attitudes defined in the *CEBOK3* that civil engineers should attain and then maintain through undergraduate and post-graduate formal education, mentored experience, and life-long self-development to serve in *responsible charge* of civil engineering services. *Responsible charge* is the legal standard for the licensed practice of engineering. Most engineering statutes closely follow the definition provided by the National Council of Examiners for Engineering and Surveying (NCEES) Model Law [2]: *The term "Responsible Charge" as used in this Act, shall mean the direct control and personal supervision of engineering work*. This includes responsibility for subordinates on the project team. An engineer serving in *responsible charge* must be a licensed professional engineer in the jurisdiction where the work is to be performed and must sign and seal their engineering deliverables.

Why is the *CEBOK3 so important to the future of civil engineering*?

Stephen J. Ressler, Ph.D., P.E., one of the driving forces for the creation of the first Civil Engineering Body of Knowledge (*CEBOK1*), defines a profession as having a professional domain (or jurisdiction exclusive to the profession) defined by a Body of Knowledge (BoK) that describes the complete set of concepts, terms, and activities that make up a professional domain. This BoK is typically defined by the relevant learned society or professional association, who then defends their jurisdiction and enforces adherence to the BoK for their professionals. However, a profession's BoK is not static. A strong profession must be able to adapt its BoK in response to emerging needs, opportunities, and threats [3][4]. ASCE has fulfilled this duty for the civil engineering profession through three editions of the *CEBOK*. The *CEBOK* will not be described in detail as there are numerous scholarly works that describe how it was developed and how it has evolved [5][6].

How rapidly do these emerging needs, opportunities and threats affect a profession's BOK? According to LinkedIn, members' skills for the same occupation changed by about 25% from 2015 to 2021. At this pace they expect skills will have changed by about 40% by 2025 [7]. This is across all industries, and civil engineering is certainly no exception.

Licensure as a Professional Engineer (PE) grants the licensee the legal authority to serve in *responsible charge* of engineering services and is broadly considered the standard to meet for *responsible charge*. However, the failure of licensure requirements to adapt to the pace of change in the world are well documented [8]. ASCE's Policy Statement 568 authoritatively states the need to attain the outcomes in *CEBOK3* for *responsible charge* [9]:

> *The American Society of Civil Engineers (ASCE)* ***supports the attainment of the Civil Engineering Body of Knowledge (CEBOK) as a requirement for exercising responsible charge in the practice of civil engineering.*** *The CEBOK defines the knowledge, skills, and attitudes necessary to exercise responsible charge in the practice of civil engineering and is attained through undergraduate and post-graduate engineering education, mentored experience, and self-development.* ***Licensure constitutes the legal authority to practice engineering, however, the requirements for licensure do not ensure attainment of the CEBOK.*** *[Emphasis added]*

In its preface, the *CEBOK3* states [1]:

> *This third edition of the Civil Engineering Body of Knowledge (CEBOK3) is focused on preparing the future civil engineer for entry into the profession. Specifically, CEBOK3 defines the knowledge, skills, and attitudes necessary for entry into the practice of civil engineering at the professional level. As described in this report, the preparation of the future civil engineer and the fulfillment of the CEBOK must include both formal education and mentored experience. Early career experience, specifically experience that progresses with increasing complexity, quality, and responsibility, and that is mentored by those who are practicing civil engineering at the professional level, is a necessary part of a civil engineer's attainment of the CEBOK. [Underline added]*

Note that the *CEBOK3* refers to *"practice of civil engineering at the professional level"*. This term is fraught with different meanings, as explained by Aldrich et al [8]. Through informal consensus of the committee that authored *CEBOK3*, this has been changed to "*responsible charge* of civil engineering services" as this was the intent of the terminology they used. This change will be reflected in future editions of the *CEBOK*.

The preface goes on to state:

> *All civil engineers, including students studying civil engineering, those who teach civil engineering, early career civil engineers, those who mentor early career engineers, those who employ civil engineers, those who design civil engineering projects, those who lead and manage groups of civil engineers and civil engineering projects, and those who conduct research in civil engineering should be interested in the CEBOK3, as we all, as members of an amazing and exciting profession, should be committed to and supportive of preparing the next generation of civil engineers.* ***This third edition of the CEBOK is the roadmap for properly preparing our future civil engineers, not for practice as we know it today, but for the profession as we expect it to be tomorrow.*** *[Emphasis added]*

The *CEBOK3* is the most comprehensive and authoritative compilation of the traits that civil engineers should attain and then maintain to serve in *responsible charge* that exists today. It identifies twenty-one outcomes covering foundational, engineering fundamentals, technical, and professional outcomes, with four interdependent steps to fulfill the various levels of achievement that comprise the KSAs necessary for *responsible charge*:

- Undergraduate (UG) education to build the foundational technical breadth and depth in a civil engineering specialty.
- Post-graduate (PG) education to provide additional depth and understanding of a civil engineering specialty.
- Structured mentored experience (ME) occurring through progressively complex work experience teaching the practice of civil engineering and rounding out technical depth while refining the professional skills necessary to prepare civil engineers for *responsible charge*.
- Life-long self-development (SD) which ensures that civil engineers stay current with trends and technological advances that affect how they practice, as the *KSAs* necessary for *responsible charge* evolve at the pace of change in the world.

Every civil engineer, regardless of where they are in their career path, should be aware of the *CEBOK3* and where they stand in personally fulfilling the outcomes. However, awareness and utilization of the *CEBOK3* is limited. Both academia and industry play a critical role in developing civil engineers for future practice and should partner to complement and support each other's role to seamlessly transition each civil engineering graduate's entry into the workforce. To be successful, civil engineering students, faculty, early-career engineers, supervisors, mentored and employers should all understand the purpose and content of the *CEBOK3*, as the roadmap for each civil engineer's career development and preparation to assume *responsible charge*.

Building awareness of the CEBOK3

If academia can build understanding and acceptance of the need to fulfill the *CEBOK3* outcomes for *responsible charge* with their students, this will help ASCE build awareness with industry, as graduates will have a solid understanding of what they still need to learn to fulfill PG, ME, and SD outcomes. The *CEBOK3* is every civil engineer's roadmap to their professional career growth, and undergraduate education is just the start of the journey. However, is this academia's responsibility?

The pathways to fulfill UG and PG outcomes in the *CEBOK3* are well established, for programs accredited by ABET, though it should be noted that PG outcomes can be filled through an advanced degree in civil engineering or other pathway that provides the necessary additional depth of technical knowledge in the individual's chosen field of practice. Consequently, academia could legitimately argue that they are meeting their obligation and that attainment of any *KSAs* not learned through formal education is not their concern, as they have no responsibility for graduates once they leave their institution. However, the goal of every academic institution should be to graduate engineers prepared to enter the workforce and thrive in their careers.

ASCE can assist in building awareness of the *CEBOK3* with academia and civil engineering students, as ASCE has well-established relationships with most civil engineering institutions through student chapters and programs that academics are engaged in. Ways to do this will be discussed in more detail later in the paper.

Industry has an obligation to help their civil engineering graduates attain and then maintain the PG, ME, and SD outcomes defined in the *CEBOK3* for *responsible charge*. However, few industry leaders are even aware of the *CEBOK3*, much less how they can use it as an invaluable tool to help them prepare their early-career civil engineers for *responsible charge*. Building awareness of the *CEBOK3* with industry is a much more difficult task as ASCE does not have the same broad nexus of association with industry leaders, that they do with academic institutions.

This is why introducing the *CEBOK3* to undergraduate civil engineering students is so essential. If civil engineering graduates have full knowledge of the *CEBOK3*, where they are on their career path and how they should pursue fulfillment of the PG, ME, and SD outcomes, **including what they should expect from their employer**, employers will take notice. But that alone will not be enough. The *CEBOK3* defines the framework for fulfilling PG, ME, and SD outcomes, but itself does not provide employers with the hands-on tools and guidance necessary to fulfill them in a practical and comprehensive way. ASCE is developing a robust and comprehensive program to fulfill the ME outcomes in the *CEBOK3*, with plans to add PG and SD outcomes later. This program will be central to ASCE's outreach to industry to help them fulfill their role and will be discussed later in the paper.

How academia should introduce the *CEBOK3*

Ideally, the *CEBOK3* is integrated into every civil engineering curriculum and first-year students are introduced to the *CEBOK3*, the duty of *responsible charge*, and the "roadmap" that will prepare them for future practice, as part of their undergraduate education. The *CEBOK3* can be aligned with course syllabi to reinforce how the courses being taken help fulfill the undergraduate education outcomes in the *CEBOK3*. Since these outcomes are closely aligned with ABET criteria for civil engineering programs, this should not prove difficult to do.

Throughout the four years of instruction, academia should continue to build understanding of what is ahead for their students once they graduate. Students should have a clear understanding that their education has only begun and that they will need to commit to continued formal education, mentored experience, and life-long self-development to maintain the necessary technical depth and breadth of understanding in their area of practice, as well as the professional skills that they should expect to learn in the workforce, to prepare them for *responsible charge*.

During their senior year, students should reflect on their progress made in fulfilling the UG outcomes, where they are in their career development and sit for the Fundamentals of Engineering (FE) exam. It is important for civil engineering graduates to have a clear understanding of what to expect when they pursue further formal education or enter the workforce.

ASCE has created a student-focused infographic to help academia introduce the *CEBOK3* to their students [10]. It also defines the role industry plays to help engineering graduates advance in their career and fulfill the outcomes defined in the *CEBOK3* that are not attained through formal education. A faculty-focused infographic explains the important role faculty play in preparing their students for the rest of their professional career [11]. ASCE also offers several other resources concerning career growth and the *CEBOK3* [12-15].

To further assist in this effort, faculty are encouraged to invite speakers from ASCE committees to review the "Engineer Tomorrow" initiative and the “roadmap” to their professional career development with their students to help build strong connections between what's being covered in the classroom, what they can expect in the workplace, and what the future holds. ASCE is exploring development of short 3–5-minute YouTube style videos by early-career engineers and practitioners to explain concepts like *responsible charge* and what to expect when you graduate, that faculty can present to their students when discussing these topics.

If successful, civil engineering graduates will know what they should expect from their employer to advance their professional career, along with the following:

- That they still need to learn the practical application of engineering principles that are best learned in the workplace.
- How the rapid pace of change will affect their practice in the future.
- What they don’t yet know, how important it will be to continually self-assess where they are in their career development, and how to continue learning in a life-long self-directed manner.
- That licensure is required, but inadequate to prepare them for *responsible charge* and that they should fulfill the *CEBOK3* first.

The duty of industry to develop civil engineers for *responsible charge*?
The practice of civil engineering is as much art as it is technical application of engineering principles. Civil engineers in *responsible charge* have a professional duty to analyze the problems they are tasked to address considering a multitude of factors (both technical and societal), to come to a preferred solution, not simply a solution that will work. Undergraduate civil engineering education provides the foundation for civil engineering practice. Post-graduate formal education enhances the civil engineer’s ability to analyze and synthesize and provides further technical depth in their area of practice.

However, formal education cannot teach the practical application of civil engineering to real-world problems only gained in the workplace (through structured mentored experience and life-long self-development) that fills out a civil engineer’s *KSAs* necessary for *responsible charge*. Industry (employers of civil engineers) have a responsibility to teach the practice and practical application of civil engineering principles.

Civil engineering consulting firms do this by assigning their civil engineers to project teams tasked with solving a variety of engineering problems. The employee is assigned progressively more complex problems to address as they gain experience and understanding of the practice of civil engineering. The objective is to prepare the civil engineer for professional licensure, which most civil engineers pursue in their career [8]. Licensure grants the legal authority to serve in *responsible charge*, however it does not ensure that the civil engineer has the necessary *KSAs* to do so. So, what do these employers do?

Employers have a duty to assign *responsible charge* only to those civil engineers who are adequately prepared to meet their professional obligations, and not all licensed PEs will rise to the level of competence for *responsible charge*. For this reason, most civil engineering

consulting firms have licensed PEs on staff who rarely if ever serve in *responsible charge* (sign and seal engineering deliverables). However, the assessment of competence is subjective and not consistently applied across the industry. As a result, the profession needs a formal way to promote and institutionalize fulfillment of the mentored experience (ME) outcomes in the *CEBOK3* to prepare their civil engineers to serve in *responsible charge*.

The above example describes what happens in private practice where most civil engineers are employed, but the situation is similar for civil engineers working in the public sector, manufacturing, and academia. There is a clear understanding of the pathway to licensure, but beyond that, a disconnect to fulfillment of the necessary *KSAs* for *responsible charge*.

Employers know there are gaps, especially in "professional skills" (communication, writing, ethical responsibilities, etc.) and wonder what to do about it. The *CEBOK3* identifies each of these skills and defines the attributes that are gained through mentored experience and life-long self-development to fulfill them. What is needed is a program that translates the content of the PG, ME, and SD outcomes into a format that employers can understand and use to develop their early-career civil engineers. ASCE is currently developing such a program (described later in this paper)

These concerns are further exacerbated by shifts in workplace culture as workers demand more flexible schedules and working conditions – a trend accelerated by necessity during the COVID 19 pandemic. LinkedIn calls these times the "Great Reshuffle" – a period unlike anything in the history of work. The pandemic sped up digital transformation, and the workplace will never be the same [16]. According to Michael Sullivan, President, and CEO of the American Council of Engineering Companies (ACEC) Georgia, "The [engineering] industry has changed, and the way that firms develop and prepare talent must change. Methods that worked in the past aren't necessarily effective today." [17]. Workers are seeking much more flexible work arrangements and simply do not want to sit in an office every day – and employers are taking notice. LinkedIn reports that 81% of executives are changing their workplace policies to offer greater flexibility to their workforce [18].

Prior to the advent of remote working, civil engineering teams were likely housed in one central office. Team members and their supervisors would interact with each other daily, and mentoring of early-career engineers was a natural extension of normal acceptable supervision. Most employers do not have a formal and structured program to mentor their subordinates, but they could monitor and help their subordinates advance their technical and professional skills as they assigned them increasingly difficult tasks and responsibilities on the project team. These face-to-face encounters among the project team were a critical element of each civil engineer's career growth.

With the shift to more flexible work arrangements industry must adapt, as daily interactions become weekly and informal conversations are stilted. For example, while it may be efficient for teams to communicate virtually via Microsoft Teams chat or Zoom meetings, employers must also prepare future civil engineers for communicating, leading, and managing projects in the real world. Learning how to deal professionally with clients and contractors when problems or conflicts occur in the field can only be learned through hands-on experience. Presenting a project

concept in a public forum is an invaluable experience for civil engineers. They must be able to concisely articulate the goals of the project and engage with the public, some of whom will be opposed for any number of reasons. These interactions go beyond learning communication skills. They reinforce the professional obligation to account for public concerns, needs and desires, and understanding of the non-technical impacts of their engineering decisions.

Similarly, project teams can interact effectively virtually, but there is no substitute for the "water cooler" discussions around a design problem, and interactions in a conference room when the entire team is developing the design concept and selecting the alternative(s) to pursue further. Some lessons that round out a civil engineer's professional development must involve face-to-face interactions with their project team, clients, contractors, and the public. ASCE intends to capture these elements of learning to help employers, mentors and mentees recognize how certain KSAs are best attained.

If ASCE is successful, employers will have a comprehensive program to help their employees fulfill ME outcomes, which should improve employee retention. LinkedIn reports that firms with robust programs for employee development nearly double the number of years that they retain employees [19]. Employers will also be able to readily identify those employees with the attitude and aptitude to strive toward *responsible charge* with a vigorous program to get them there.

Industry needs a clear understanding of why the *CEBOK3* is relevant to their organization and how they can use it as a tool to prepare their civil engineers to assume *responsible charge*. Further, as the *CEBOK* is periodically updated to reflect trends that affect civil engineering practice, and program content is revised to reflect those updates, this program can help industry and their civil engineers stay current and maintain those *KSAs* necessary for *responsible charge*. This can be achieved if:

- Academia successfully introduces the *CEBOK3* to their engineering students.
- Civil engineering graduates understand the next steps in their career development and are prepared to pursue the ME outcomes with their employer.
- ASCE creates a successful program to map the progression of activities necessary to fulfill the ME outcomes in a robust, comprehensive, and user-friendly way.
- Industry understands, accepts, and utilizes the ME fulfillment program as a valuable career development tool for their early-career civil engineers.

Converting the *CEBOK3* into a hands-on tool

The *CEBOK3* is a reference standard that defines the KSAs necessary for *responsible charge* of civil engineering services. It can be used like any other code or standard that civil engineers use in everyday practice. However, unlike other codes and standards, the standards defined in the *CEBOK3* are a progression of steps to gain aptitude and skill in different facets of civil engineering practice over time and through different inter-dependent pathways.

It is generally accepted that UG outcomes are fulfilled with a degree in civil engineering from an ABET accredited program and that PG outcomes can be fulfilled with an advance degree in civil engineering from an institution with an accredited program (undergraduate and/or graduate level) in civil engineering. What is needed are tools to help civil engineers attain PG outcomes not

fulfilled through an advance degree, ME outcomes and SD outcomes of the *CEBOK3*. ASCE recognizes that the most critical need is to develop a robust program to fulfill the ME outcomes and has started development. The intent is to create a program to validate fulfillment of each ME outcome that has robust content to map each civil engineer's progression, is user-friendly, easy to understand, simple to track, and portable. It will likely take 3-4 more years to develop the program before implementation.

How the mentored experience outcomes are defined in the *CEBOK3* allow the program to have a self-directed approach, where early-career engineers can develop these skills through both self-directed learning and interaction with supervisors and colleagues – both in-person and remotely. This way, mentees can have direct control of the progression of their learning. Mentors will find the program very functional as well, providing them with practical content and activities to assist them in developing their mentees. This also recognizes that not all mentoring must be performed in the workplace. Some mentoring can (and does) occur through contact with peers and others outside the workplace.

What will be needed is clear guidance on the progression of learning for each outcome in a logical way that both early-career civil engineers and their mentors/supervisors can understand, implement, and track. Also, like the *CEBOK*, which is periodically updated to reflect how the pace of change in the world is changing civil engineering practice, the program content will evolve to reflect these changes as well.

The program would eventually be augmented with guidance and support to fulfill PG outcomes attained through alternative pathways to a post-graduate degree and SD outcomes to ensure that they keep the individual abreast of changes in their area of practice.

It is anticipated that most civil engineers will obtain their PE license before fulfilling all the outcomes, and not all civil engineers will choose to complete the program. That is fine, as not all civil engineers will serve in *responsible charge* in their career. However far an individual civil engineer progresses through the program, they will be well served with important skills that they might not have gained otherwise.

If successful, this program could achieve four important goals:

1. Build awareness of the *CEBOK3* and the importance of fulfillment of the *KSAs* necessary for *responsible charge* to both employers and civil engineers alike.
2. Be portable and individualized as employees who change jobs during the process do not want to lose their progress or documentation of what they've already attained.
3. Open opportunities for mentoring relationships outside employment, as some ME outcomes can be effectively completed with a mentor and mentee working remotely and not in the same organization.
4. Define a certification program, uniformly accepted by industry, to document each civil engineer's progression through the outcomes.
5. Subsequently incorporate PG and SD outcomes to complete validation of the entire *CEBOK3*.

How can academia and industry partner to seamlessly transition graduates?
Although there is collaboration between industry, academia, and students through internships, presentations at student chapter meetings, and industry professionals serving as advisors for senior design projects, and other similar interactions, industry should better coordinate with academia to support a seamless transition for graduates from school to industry and the rest of their professional development. Focusing this collaboration on the *CEBOK3* would provide more clarity and purpose to what is already being done and help build better connections between what students learn through their undergraduate education, and what they should expect the rest of their career development to look like.

A significant constraint to any collaboration is time. Academics must find time to fold the *CEBOK3* into their lesson plans. ASCE can help in this effort with resources – publications, videos, presentations, etc. Industry will have similar concerns as many already invest in interactions with their chosen institution(s) and might be reluctant to "take on anything more". However, this initiative should not be adding more time to these interactions. It should simply be focusing them on a clear purpose – fulfillment of the KSAs in the *CEBOK3*. The payback for academics is a bridge to industry as graduates are seamlessly handed off. The payback for industry is a clearer focus on how to engage with students and intake new graduates to advance them along their career path.

How and when industry engages with students is closely regulated by academia as these interactions must fit into the student's instruction and activities. Industry needs to respect this and find ways to engage that fit into each instructor's plans. The intent is not to add more content to an already full curricula, but to bring clarity, focus and value to what is already happening. Every institution has different needs, and levels of engagement with industry so ultimately this needs to be driven by each institution to fit within their educational plans. Therefore, industry must be flexible and open to various methods to engage. Instructors should consider how and when to solicit industry to help them introduce and incorporate the *CEBOK3* into their instruction.

ASCE should engage with civil engineering educators through the various connections they have to discuss how to promote and integrate the *CEBOK3* into their curricula and how ASCE can educate/assist industry to interact with them to bring focus and value to the instruction. Through experimentation and evaluation ASCE should develop a series of "best practices" to improve efficiency and effectiveness. ASCE can also develop tools for industry to help them efficiently and effectively present aspects of the *CEBOK3* when asked to do so. This could include You Tube style or live video interactions that could take as little as 3-5 minutes of class time, with prepared "talking points" for a uniform and consistent message.

To build this partnership between academia and industry the following is needed:

1. Academia needs to fold the *CEBOK3* into their curricula and introduce the principles to their civil engineering students.
2. ASCE should interact with faculty through their Committee on Education and other interactions with academia to determine how they can promote and support this effort.

3. Academia should determine how/when to engage industry to bring focus and value to the instruction.
4. Each institution and their industry partners should assess existing interactions to determine how they can refocus on the *CEBOK3* and what new interactions would bring focus and value.
5. Industry should recognize the value of this engagement and find opportunities for effective outreach to students.

Conclusions

1. The pace of change in the world directly impacts how civil engineers practice today and will practice in the future.
2. Reflecting the state of civil engineering today, the *CEBOK3* defines the necessary *KSAs* that all civil engineers who assume *responsible charge* of civil engineering services should attain and then maintain, to protect and advance public health, safety, and welfare.
3. These *KSAs* will evolve at the pace of change and the *CEBOK* must be periodically updated to reflect these impacts.
4. Licensure constitutes the legal authority to practice in *responsible charge*; however, licensure requirements have not kept up with the pace of change in the world, do not ensure attainment of the *CEBOK*, and do not adequately protect and advance public health, safety. and welfare.
5. All civil engineers should attain and maintain the KSAs defined in the *CEBOK3* (and as periodically updated) prior to assuming *responsible charge* of civil engineering services.
6. The entire spectrum of the civil engineering profession from students and faculty to early-career engineers, supervisors, mentors, and employers need to understand the importance of the *CEBOK3* and strive to incorporate it into their career development.
7. Building awareness and acceptance of the *CEBOK3* outcomes is critical to the future success of the profession. Unfortunately, awareness of the *CEBOK3* is extremely limited.
8. Academia should introduce the *CEBOK3* to their first-year civil engineering students, align the UG levels of achievement into syllabi and curricula and build a solid understanding of its purpose and use with all students. ASCE has publications and other programs to assist in this effort.
9. Graduates should have a clear understanding of the importance of the *CEBOK3*, how it lays out the roadmap to their professional career growth, where they are along the pathway, and what is expected of them and their employer to fulfill those KSAs not attained through UG activities. ASCE has publications and other programs to assist in this effort.
10. Industry has a professional duty to only grant authority for *responsible charge* to those employes who have the required *KSAs*, and a responsibility to provide the resources needed to fulfill the outcomes not provided through undergraduate education.
11. Industry needs a robust program to facilitate attainment of the ME outcomes that is well-designed, uniformly accepted, and utilized. Facilitating fulfillment of PG and SD outcomes can be built from this program. ASCE, as the recognized leader of the civil engineering profession, and author of the *CEBOK3*, is the logical entity to create such a program and is pursuing the same.

Next Steps

1. All civil engineering education programs should develop methods to integrate the *CEBOK3* into their curricula with the objective that all graduates understand the concept of *responsible charge*, that licensure alone is inadequate preparation, and why they should pursue fulfillment of the outcomes of the *CEBOK3* as a career milestone. ASCE should assist in this effort.
2. ASCE should develop tools to introduce the *CEBOK3* to industry and ways to refocus their interactions with academia to help academia introduce the *CEBOK3* to their students.
3. ASCE should develop a hands-on tool to guide mentees and mentors on how to fulfill the ME outcomes in the *CEBOK3*.

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