Here We Go Again: Civil Engineering Body of Knowledge, Fourth Edition

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Introduction

The American Society of Civil Engineers (ASCE) Civil Engineering Body of Knowledge (CEBOK) Third Edition (CEBOK3) was published in 2019 [1]. Much like the prior versions of the CEBOK, the Third Edition made significant positive impacts on the profession of civil engineering as it outlines foundational, technical, and professional practice learning outcomes for individuals entering into responsible charge in the practice of civil engineering. CEBOK sets the direction for curriculum development and professional practice and sets an expectation for lifelong learning. As part of a pre-established timeline, ASCE has launched the Civil Engineering Body of Knowledge Task Committee, Fourth Edition (CEBOK4TC).

The following charge was presented to the CEBOK4TC by the ASCE Committee on Education leadership:

- Critically review published literature regarding the future of engineering, other disciplines, and civil engineering practice;
- Evaluate the Third Edition of the Civil Engineering Body of Knowledge (CEBOK3);
- Proactively solicit constituent input;
- Determine if a Fourth Edition of the Civil Engineering Body of Knowledge (CEBOK4) report is warranted; and,
- If warranted, develop the CEBOK4 report.

The intent of this paper is to provide a summary of the history behind previous editions of the CEBOK and how they have guided ASCE's activities to advance the educational objectives of the profession. Further, this paper documents the process that the CEBOKTC has completed to date in response to its charge and provides an outline of the path that lies ahead for the CEBOK4TC.

CEBOK Background

In February 2004, after nearly two years of intense work, the BOK Committee, which at that time was a constituent committee of the Committee on the Academic Prerequisites for Professional Practice (CAP^3), published the first-ever Civil Engineering Body of Knowledge (CEBOK1) [2]. The CEBOK1 defined "the knowledge, skills, and attitudes necessary to become a licensed professional engineer" through 15 outcomes. The CEBOK1 used ABET Criterion 3 student outcomes a - k from that time for the first 11 outcomes and all the outcomes were distinguished along three broad levels of competence: Level 1 (Recognition), Level 2 (Understanding), and Level 3 (Ability) [2, 3].

Table 1 CEBOK1 Outcomes [2, 3]

Outcome	Outcome Statement	Level	ABET
1. Technical Core	an ability to apply knowledge of mathematics, science, and engineering	Ability (3)	a
2. Experiment	an ability to design and conduct experiments, as well as analyze and	Ability (3)	b

	interpret results		
3. Design	an ability to design a system, component, or process to meet desired needs	Ability (3)	c
4. Multidisciplinary	an ability to function on multi-disciplinary teams	Ability (3)	d
5. Engineering Problems	an ability to identify, formulate, and solve engineering problems	Ability (3)	e
6. Professional/ Ethical	an understanding of professional and ethical responsibility	Understanding (2)	f
7. Communication	an ability to communicate effectively	Ability (3)	g
8. Engineering Impact	the broad education necessary to understand the impact of engineering solutions in a global and societal context	Understanding (2)	h
9. Life-long Learning	a recognition of the need for, and an ability to engage in life-long learning	Ability (3)	i
10. Contemporary Issues	a knowledge of contemporary issues	Recognition (1)	j
11. Engineering Tools	an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	Ability (3)	k
12. Specialized Area	an ability to apply knowledge in a specialized area related to civil engineering	Ability (3)	N/A
13. Project Management, Construction, and Asset Management	an understanding of the elements of project management, construction, and asset management	Understanding (2)	N/A
14. Business and Public Administration	an understanding of business and public policy and administration fundamentals	Understanding (2)	N/A
15. Leadership	an understanding of the role of the leader and leadership principles and attitudes	Understanding (2)	N/A

In October 2005, not long after the publication of CEBOK1, the Second Edition of the Body of Knowledge Committee Task Committee (CEBOK2TC) was formed. This was partly in response to the publication of several strategic vision documents that were published or being prepared

that called for future engineers to develop certain knowledge, skills, and attitudes that had not been included in CEBOK 1 [3].

Another issue that developed as ASCE submitted proposed new accreditation criteria to the Engineering Accreditation Commission of ABET that were CEBOK1 compliant, was that the outcomes of the CEBOK did not lend themselves to effective measurement, specifically with regard to the three levels of competency. To address this issue ASCE formed a subcommittee that made recommendations for inclusion in a future version of the CEBOK [4].

Starting with those recommendations and examining other critical issues, the CEBOK2TC published the Civil Engineering Body of Knowledge for the 21st Century, Second Edition in 2008 (CEBOK2) [5]. Some of the important and significant differences in CEBOK2 from CEBOK1 included [3]:

- Increasing the number of outcomes and categorizing the outcomes
- Using Bloom's Taxonomy for levels of achievement
- Establishing paths to fulfillment for the outcomes
- Including a full rubric beyond the level of achievement required for the CEBOK
- Including extensive appendices describing the outcomes and various other aspects of the CEBOK

The number of outcomes (see Table 2) increased from 15 to 24 and were organized into three categories: Foundational, Technical, and Professional. The increase in outcomes reflected the committee's desire to improve clarity and specificity, rather than to increase the scope of the CEBOK. CEBOK2 outcomes did signal a greater emphasis on some topics including the natural sciences, the humanities, sustainability, globalization, risk and uncertainty, and public policy [3].

Table 2 CEBOK2 Outcomes [3, 5]

Outcome	**Outcome Statement**	**Level**[1]
Foundational		
1. Mathematics	**Solve** problems in mathematics through differential equations and **apply** this knowledge to the solution of engineering problems.	Application (3)
2. Natural Sciences	**Solve** problems in calculus-based physics, chemistry, and one additional area of natural science and **apply** this knowledge to the solution of engineering problems.	Application (3)
3. Humanities	**Demonstrate** the importance of the humanities in the professional practice of engineering.	Application (3)
4. Social Sciences	**Demonstrate** the incorporation of social sciences knowledge into the professional practice of engineering.	Application (3)

Technical		
5. Materials Science	**Use** knowledge of materials science to **solve** problems appropriate to civil engineering.	Application (3)
6. Mechanics	**Analyze** and **solve** problems in solid and fluid mechanics.	Analysis (4)
7. Experiments	**Analyze** the results of experiments and **evaluate** the accuracy of the results within the known boundaries of the tests and materials in or across more than one of the technical areas of civil engineering.	Synthesis (5)
8. Problem Recognition and Solving	**Formulate** and **solve** an ill-defined engineering problem appropriate to civil engineering by selecting and applying appropriate techniques and tools.	Analysis (4)
9. Design	**Evaluate** the design of a complex system, component, or process and **assess** compliance with customary standards of practice, user's and project's needs, and relevant constraints	Evaluation (6)
10. Sustainability	**Analyze** systems of engineered works, whether traditional or emergent, for sustainable performance.	Analysis (4)
11. Contemporary Issues & Historical Perspectives	**Analyze** the impact of historical and contemporary issues on the identification, formulation, and solution of engineering problems and **analyze** the impact of engineering solutions on the economy, environment, political landscape, and society.	Analysis (4)
12. Risk and Uncertainty	**Analyze** the loading and capacity, and the effects of their respective uncertainties, for a well-defined design and **illustrate** the underlying probability of failure (or nonperformance) for a specified failure mode.	Analysis (4)
13. Project Management	**Formulate** documents to be incorporated into the project plan.	Analysis (4)
14. Business and Public Administration	**Analyze** and **solve** well-defined engineering problems in at least four technical areas appropriate to civil engineering.	Analysis (4)
15. Technical Specialization	**Evaluate** the design of a complex system or process, or **evaluate** the validity of newly created knowledge or technologies in a traditional or emerging advanced	Evaluation (6)

	specialized technical area appropriate to civil engineering.	
Professional		
16. Communication	**Plan**, **compose**, and **integrate** the verbal, written, virtual, and graphical communication of a project to technical and nontechnical audiences.	Synthesis (5)
17. Public Policy	**Apply** public policy process techniques to simple public policy problems related to civil engineering works.	Application (3)
18. Business and Public Administration	**Apply** business and public administration concepts and processes.	Application (3)
19. Globalization	**Analyze** engineering works and services in order to function at a basic level in a global context.	Analysis (4)
20. Leadership	**Organize** and **direct** the efforts of a group.	Analysis (4)
21. Teamwork	**Function** effectively as a member of a multidisciplinary team.	Analysis (4)
22. Attitudes	**Demonstrate** attitudes supportive of the professional practice of civil engineering.	Application (3)
23. Lifelong Learning	**Plan** and **execute** the acquisition of required expertise appropriate for professional practice.	Synthesis (5)
24. Professional and Ethical Responsibility	**Justify** a solution to an engineering problem based on professional and ethical standards and **assess** personal professional and ethical development.	Evaluation (6)

[1]Based on Bloom's Taxonomy (cognitive domain)--Knowledge (1), Comprehension (2), Application (3), Analysis (4), Synthesis (5), Evaluation (6) [6]

From 2016-2019 the Civil Engineering Body of Knowledge 3 Task Committee (CEBOK3TC) developed and published the Third Edition of the Civil Engineering Body of Knowledge (CEBOK3). This edition featured several significant and substantive changes from CEBOK2. These changes included [1, 3]:

- Revising the definition of the CEBOK
- Reducing the number of outcomes from 24 to 21 and adding an outcome category (see Table 3)
- Confirming the use of Bloom's Taxonomy for levels of achievement and reducing the number of action verbs used
- Incorporating the use of Bloom's Taxonomy in the Affective Domain for 7 of the 21 outcomes (see Table 4)

- Revising the typical paths to fulfillment
- Changing the format
- Recommending the development of companion materials to communicate important aspects of the CEBOK to various stakeholder groups

Both CEBOK1 and CEBOK2 defined the knowledge, skills, and attitudes necessary for entry into the practice of civil engineering at the professional level, where "entry into the practice of civil engineering at the professional level" was defined as becoming licensed as a professional engineer (PE)" [3]. While the CEBOK3 supports licensure and recognizes licensure as an important aspect of the civil engineering profession, the CEBOK3TC desired to separate CEBOK and recognize its distinctiveness from licensure. Based on this understanding the CEBOK3 does not have a direct link to licensure. This was an effort to acknowledge and affirm that the CEBOK applies to all civil engineers regardless of career path or area of practice [3].

The CEBOK3 contains 21 outcomes in four categories as shown in Table 3, a change from the 24 outcomes divided into three categories in CEBOK2. The CEBOK3 kept the three categories from BOK 2 and added a new fourth category - engineering fundamentals. Outcomes listed as foundational provide the knowledge on which all other outcomes are built for both civil engineers and those in most other learned professions. The engineering fundamentals outcomes form a bridge between the foundational and technical outcomes for all civil engineers, and not surprisingly for many of the other engineering disciplines. Knowledge that is more specific to civil engineering is contained in the technical outcomes. The professional outcomes highlight the interpersonal and professional skills necessary for success at the professional level in civil engineering [3].

Table 3 CEBOK3 Outcomes and Levels of Achievement in the Cognitive Domain. [1, 3]

Outcome	**Outcome Statement**	**Level**[2]
Foundational Outcomes		
Mathematics	**Apply** concepts and principles of mathematics, including differential equations and numerical methods, to solve civil engineering problems.	Apply (3)
Natural Sciences	**Apply** concepts and principles of chemistry, calculus-based physics, and at least one other area of the natural sciences, to solve civil engineering problems.	Apply (3)
Humanities	**Apply** aspects of the humanities to the solution of civil engineering problems.	Apply (3)
Social Sciences	**Apply** concepts and principles of social sciences relevant to civil engineering.	Apply (3)

Engineering Fundamentals Outcomes		
Materials Science	**Apply** concepts and principles of materials science to solve civil engineering problems.	Apply (3)
Engineering Mechanics	**Apply** concepts and principles of solid and fluid mechanics to solve civil engineering problems.	Apply (3)
Experimental Methods & Data Analysis	**Select** appropriate experiments, and **analyze** the results in the solution of civil engineering problems.	Analyze (4)
Critical Thinking & Problem Solving	**Develop** a set of appropriate solutions to a complex problem, question, or issue relevant to civil engineering.	Synthesize (5)
Technical Outcomes		
Project Management	**Apply** concepts and principles of project management in the practice of civil engineering.	Apply (3)
Engineering Economics	**Apply** concepts and principles of engineering economics in the practice of civil engineering.	Apply (3)
Risk and Uncertainty	**Select** appropriate concepts and principles of probability and statistics to analyze risk in a complex civil engineering problem.	Analyze (4)
Breadth in a Civil Engineering Area	**Analyze** complex problems that cross multiple specialty areas appropriate to the practice of civil engineering.	Analyze (4)
Design	**Develop** an appropriate design alternative for a complex civil engineering project that considers realistic requirements and constraints.	Synthesize (5)
Depth in a Civil Engineering Area	**Integrate** advanced concepts and principles into the solutions of complex problems in a specialty area appropriate to the practice of civil engineering.	Synthesize (5)
Sustainability	**Analyze** systems of engineered works, whether traditional or emergent, for sustainable performance.	Analyze (4)
Professional Outcomes		
Communication	**Integrate** different forms of effective and persuasive communication to technical and non-technical	Synthesize (5)

	audiences.	
Teamwork & Leadership	**Integrate** concepts and principles of effective teamwork and leadership, including diversity and inclusion, into the solutions of civil engineering problems.	Synthesize (5)
Lifelong Learning	**Illustrate** professional attitudes relevant to the practice of civil engineering, including creativity, curiosity, flexibility, and dependability.	Synthesize (5)
Professional Attitudes	**Illustrate** professional attitudes relevant to the practice of civil engineering, including creativity, curiosity, flexibility, and dependability.	Analyze (4)
Professional Responsibilities	**Integrate** professional responsibilities relevant to the practice of civil engineering, including safety, legal issues, licensure, credentialing, and innovation.	Synthesis (5)
Ethical Responsibilities	**Develop** courses of action to ethical dilemmas in complex situations.	Synthesis (5)

[2]Based on Bloom's Taxonomy (cognitive domain), using verb form for the names of the levels--Remember (1), Comprehend (2), Apply (3), Analyze (4), Synthesis (5), Evaluation (6) [6, 7].

Table 4 CEBOK3 Outcomes and Levels of Achievement in the Affective Domain. [1, 3]

Outcome	**Outcome Statement**	**Level**[3]
Technical Outcomes		
Sustainability	**Integrate** a commitment to sustainability principles into the practice of civil engineering.	Organize (4)
Professional Outcomes		
Communication	**Display** effective and persuasive communication to technical and non-technical audiences.	Organize (4)
Teamwork & Leadership	**Display** effective teamwork and leadership, including support of diversity and inclusion.	Organize (4)
Lifelong Learning	**Establish** a lifelong learning plan to support one's own professional development.	Organize (4)
Professional Attitudes	**Establish** professional attitudes relevant to the	Organize (4)

	practice of civil engineering, including creativity, curiosity, flexibility, and dependability.	
Professional Responsibilities	**Form** judgments about professional responsibilities relevant to the practice of civil engineering including safety, legal issues, licensure, credentialing, and innovation.	Organize (4)
Ethical Responsibilities	**Advocate** for ethical behavior in the practice of civil engineering.	Characterize (5)

[3]Based on Bloom's Taxonomy (affective domain),--Receive (1), Respond(2), Value (3), Organize (4), Characterize (5) [8]

CEBOK3 recognizes the need for civil engineers to internalize and have a value system that supports practice at the professional level, as seen by the addition of the affective domain to the CEBOK. The CEBOK3TC acknowledged that civil engineers are also responsible for their own individual development and established self-development as a new pathway component to fulfilling the CEBOK along with undergraduate education, postgraduate education, and mentored experience. Of note in CEBOK3 is an increased focus on mentored experience as the pathway required to meet outcomes required for entry into the practice of civil engineering [3].

Current Task Committee Formation

The leadership team for the CEBOK4TC, consisting of a Committee Chair, Committee Vice Chair, Editor, and ASCE Staff Liaison was appointed by the ASCE Committee on Education in Spring 2024. That leadership team generated a call for task committee membership, which was issued via email and ASCE news outlets in June 2024. A total of 40 individuals responded to the call for committee membership with individual respondents declaring their position interest (voting committee member and/or corresponding member), prior experience with the CEBOK, employment position, and basic demographic information. The leadership team reviewed all applications and made a concerted effort to form a team representing a diverse cross-section of ASCE membership. Specific effort was made to ensure a relatively balanced distribution of academic and industry representation. The resulting task committee consists of 12 voting committee members and 31 corresponding members. Individuals interested in joining the task committee as corresponding members are welcome to do so throughout the process. A list of voting committee members, along with affiliation, is provided in Appendix A.

Review of Literature

The first item in the charge presented to the CEBOK4TC was to perform a critical review of published literature regarding the future of engineering, other disciplines, and civil engineering practice. To accomplish this item and in recognition of the volume of literature encompassed in this activity, the task committee subdivided into three subgroups. Each subgroup was tasked with reviewing a particular type of literature.

Review of Body of Knowledge Documents Published by Other Organizations – This subgroup reviewed a total of 8 Body of Knowledge reports as published by other professional organizations between 2009 and 2024 [9-16]. These BOK reports were published by

organizations including the National Society of Professional Engineers, the International Engineering Alliance, the Institute of Industrial and Systems Engineers, and the European Federation of National Maintenance Societies, among others.

Review of American Society for Engineering Education Papers Related to CEBOK3 – This subgroup reviewed a total of 12 papers published in the proceedings of the American Society for Engineering Education (ASEE) Annual Conference and Exposition between 2017 and 2020 [3, 17-27]. Several of those papers provided an update or a summary of the process used in the development of the CEBOK3, while a handful of those papers used the CEBOK3 to evaluate program conditions or to compare with ABET Program Criteria in use at that time.

Review of Literature Related to the Future Needs of the Civil Engineer – This subgroup reviewed 10 articles, reports, essays, etc. with content related to the future of the civil engineering profession [28-37]. Each of these documents were published between 2007 and 2024. The literature reviewed by this subgroup included discussions of the rapidly evolving role of artificial intelligence in civil engineering, nanotechnologies, innovative materials, and sustainability in a rapidly changing environment.

Literature Evaluation

Each task committee sub-group approached their critical review of published papers, reports, and other documents with the following series of questions in mind:

- Does the source affirm aspects of the ASCE BOK3? Is so, what and how?
- Does the source suggest things that may need to be revised or clarified in the BOK? Is so, what, why, and how?
- Does the source suggest things that are missing and should be considered for addition? If so, what, why, and how?
- Does the source suggest things that should be removed from the BOK? If so, what and why?

Review of Body of Knowledge Documents Published by Other Organizations – Common across most BOKs reviewed was the incorporation of multiple domains. One of the reviewed BOKs included not only the cognitive domain and affective domain but also to a limited extent the psychomotor domain. The subgroup noted that the way content was presented varied widely. No specific knowledge, skills, or attributes were identified as missing and should be considered for addition as a result of reviewing the other BOKs. Nor did the review of other BOKs result in the suggestion that items should be removed from the CEBOK. However, it was noted that some other BOKs included materials designed to better engage students and practitioners, such as specific descriptions of how the BOKs might apply to career paths, narrative stories of hypothetical professionals, and their educational and career paths, and also specific tools to provide guidance on the mentored experience phase of professional development. Tying into other ASCE resources such as the Engineering Grades and mentoring resources would enhance the applicability of the BOK and potentially speak to a broader audience of civil engineers at various stages in their careers.

Review of American Society for Engineering Education Papers Related to CEBOK3 – The bulk of the ASEE conference papers reviewed by this subgroup consisted of updates during the process that the CEBOK3TC was engaged with and/or summary papers written after the

CEBOK3 was complete. Thus, the reviewed papers really did not have the intent of affirming content in the CEBOK3, nor did it point towards items that were missing. The subgroup reviewed one ASEE paper that summarized a constituent survey conducted with respect to a draft version of the CEBOK3. Some constituent feedback did refer to outcomes that were not in CEBOK3. Presumably, the CEBOK3TC did consider that constituent feedback and opted to not incorporate those specific outcomes.

Review of Literature Related to the Future Needs of the Civil Engineer – The subgroup determined that the literature related to the future needs of the Civil Engineer seems to affirm the CEBOK3, in general. Specifically, documents such as the Vision for Civil Engineering in 2025 [30, 31] appear to be accurate relative to the competencies identified in the CEBOK3, and although originally developed in 2006, effectively foresaw the development of the profession. The literature reviewed by this subgroup did suggest three items that warrant revision or clarification: public policy/public advocacy, leadership and management, and sustainability. Specific to possible areas that are missing in the CEBOK3, this subgroup noted the increased role of artificial intelligence in the profession subsequent to the publication of the CEBOK3. Nothing in the CEBOK3 was suggested as obsolete as a result of this subgroups' literature review.

CEBOK4TC Recommendation

After carefully reviewing and evaluating the literature previously presented herein, it was the unanimous decision of the committee to recommend that revisions to the CEBOK3 were warranted. Accordingly, the committee has proceeded with the follow-on step in their charge, which is the development of the CEBOK4 report. The reviewed literature was instrumental in reaching this recommendation and will help inform the committee's future work.

The CEBOK4TC will give consideration to the following items as they move forward:

- Potential incorporation of the psychomotor domain.
- Reorganization of how the BOK content is presented to make it more engaging.
- Better engagement with a wide cross-section of members of the profession.
- Stronger emphasis and/or clarification on the topics of public policy/public advocacy, leadership and management, and sustainability.
- Addition of specific content related to artificial intelligence.

CEBOK4TC In-Person Meeting

In addition to bi-weekly online meetings, the CEBOK4TC convened at the ASCE Headquarters in Reston, VA for its first in-person meeting in late February 2025. During that meeting members of the committee conducted a stakeholder analysis, performed a review and analysis of each of the 21 CEBOK3 outcomes, and explored new methods for publication and distribution of CEBOK4. Corresponding members of the task committee were provided the opportunity to connect with the meeting and engage via online resources.

CEBOK4TC Path Forward

As we engage in this two-year process the CEBOK4TC has the advantage of being able to benefit from and build on the many lessons learned through the development and implementation

of the first three editions of the CEBOK. One of our first tasks, Phase I, will be to continue to conduct and complete the comprehensive and critical review of published papers, reports, and other documents, as noted previously. The committee will also be working to develop a strategic vision for what is required to prepare the future civil engineer as part of this phase.

Provided with this rich background [27], the CEBOK4TC will set to work on completing what will likely be four additional phases of work required to be accomplished. Phase II will encompass developing a pre-draft version of the CEBOK4 outcomes. Following that, Phase III will include an assessment of the pre-draft CEBOK outcomes, drafting rubrics and explanations for each outcome, and seeking further input from constituents. Simultaneous to all phases in the CEBOK4 development process will be a rigorous and determined effort of stakeholder and constituent outreach and engagement. The effort will include the identification of stakeholders and constituencies, developing appropriate tools and methods for collecting input and feedback, planning for the widespread disbursement of these tools and methods, and a careful and thoughtful analysis of the feedback and input received. As part of this focused effort, the committee will look internally for members with extensive experience in designing and conducting surveys and analyzing the results or seek to bring in outside assistance for this critical task.

Phase IV will be focused on the development of a first draft of the new CEBOK4 and finalizing drafts of rubrics and explanations for each outcome. We will continue to seek further input from stakeholders and constituency groups through formal surveys and presentations to constituency groups.

Phase V will be the evaluation of all constituency and stakeholder feedback and input, and then the development of a final draft of the new edition of the CEBOK. An important aspect of this phase is effective communication to ensure it is understood, accessible, and applicable to the broad range of civil engineering professional practice. Phase VI will be the publication of and widespread distribution of the new CEBOK4. This will require the development of a communications strategy and tools to reach key stakeholders and constituencies, including other ASCE committees and groups that will be tasked with implementation aspects of the CEBOK. While a great deal of challenging work and effort faces the CEBOK4TC, it is an important as well as an inspiring task that the committee is looking forward to meeting.

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