Engineering Educators Bringing the World Together
2025 ASEE Annual Conference & Exposition
Palais des congrès de Montréal, Montréal, QC • June 22–25, 2025 ASEE
Paper ID #45984

Towards a Refresh of the Environmental Engineering Body of Knowledge

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Towards a Refresh of the Environmental Engineering Body of Knowledge

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Abstract

The original version of the Environmental Engineering Body of Knowledge (EEBOK1) was first published in 2009 by the American Academy of Environmental Engineers (now the American Academy of Environmental Engineers and Scientists, AAEES, or Academy). In 2018, a volunteer task force was formed by the Academy with input from the Association of Environmental Engineering and Science Professors (AEESP or Association). In 2018, the task force recommended a refresh of the EEBOK1. In 2021, the Environmental Engineering Division of the American Society for Engineering Education (ASEE, Society) hosted a panel discussion about the EEBOK1. Through a series of articles, input was sought from a breadth of professional and technical organizations. In 2024, an ad hoc group was formed by the Academy with input from the Association. In 2024, the ad hoc group conducted a survey of diverse stakeholders. A total of 28 responses were received. The ad hoc group reviewed the responses and recommended the updating of the Executive Summary as well as Outcome 17. This article shares the results of the survey conducted in 2024 as well as proposed language that could be considered in a refresh and creation of EEBOK2, including an updated Executive Summary as well as an updated Outcome 17.

Introduction

Originally published in 2009, the Environmental Engineering (EE) Body of Knowledge (BOK) begins with an introduction explaining that a Body of Knowledge Development Task Force was created by the Board of Trustees of the American Academy of Environmental Engineers (now the American Academy of Environmental Engineers and Scientists, AAEES, or Academy) in 2005 and charged with, “defining the BOK needed to enter the practice of environmental engineering at the professional level (licensure) in the 21st century,” [1]. The introduction concludes that, “the EnvE BOK is not intended to be prescriptive, but instead to be directional, forward looking; and more of a compass than a detailed road map,” [1].

In 2018, the Academy formed a volunteer task force to, “evaluate if changes are needed to the 2009 Environmental Engineering BOK, and if necessary, propose a process to prepare the 2019 Environmental Engineering BOK2,” [2]. The results from this volunteer task force were shared with the leadership of the Academy and the leadership of the Association of Environmental Engineering and Science Professors (AEESP, or Association).

In 2021, a panel discussion of the EEBOK1 was organized by the Environmental Engineering Division of the American Society of Engineering Education (ASEE, or Society) as part of the 2021 annual conference and exposition. A summary of that discussion was published in the journal Environmental Engineering Science [3]. Additional editorials and commentaries inviting discussion of the EEBOK1 were published in the Journal of Environmental Engineering, ASCE [4], Water Environment Research [5], and Journal AWWA [6].

In an effort to solicit additional input, in 2024, an *ad hoc* group of members of the Academy and the Association constructed an online survey instruction, which was then distributed broadly to diverse stakeholders. Targeted groups invited to offer input included: 1) those who previously participated in the 2018 volunteer task force; 2) current members of the Association's education committee; 3) current members of the Academy's expertise and examination committee; 4) current members of the Academy's judging panel for the annual excellence in environmental engineering and science competition; 5) current ABET Inc program evaluators of environmental engineering and similarly named programs; 6) a list of current faculty leaders of ABET Inc accredited environmental engineering and similarly named programs; and 7) a list of current members of the National Academy of Engineering in section 4 – civil & environmental.

The *ad hoc* group of members of the Academy and the Association met to review the results of the survey. The purpose of this current article is to share the results of the survey and suggested changes that could be considered as part of a refresh of the EEBOK2 (also known as EEBOK2).

Methods

Since the original publication of the EEBOK1 in 2009, a number of parallel efforts have been undertaken by AAEES, by engineering and technical organizations, and by individuals and teams of researchers that have influenced – directly and indirectly – the field of environmental engineering. To inform improvements in the EEBOK2, working groups have examined a diverse body of literature. Three thematic areas were examined. These three areas included: 1) changes within the profession of environmental engineering; 2) changes within the broader practice of engineering; and 3) changes within the adjacent field of environmental science.

Within the profession of environmental engineering, six specific items were highlighted. First, in 2010, the AAEES added an eighth subspeciality for the in the area of environmental sustainability [7]. Second, in 2015, the AAEES launched the, "Patrons Program," as a way to formally increase engagement with and financial support from organizations such as consulting firms and utilities. Third, in 2019 the NASEM published, "Environmental engineering for the 21st century: Addressing grand challenges," which outlined five areas where the profession of environmental engineering is uniquely poised to help to solve [8]. Fourth, in 2021, the AAEES Board of Trustees adopted the, "AAEES Ethics Statement," which identifies four canons. The four canons include: 1) professionalism and competency; 2) public health, environmental stewardship, and sustainability; 3) respect, dignity, and equity; and 4) advancing the profession (AAEES 2021). Fifth, in January 2022 the AAEES Board of Trustees ratified the vote of the membership of the AAEES to modify the Bylaws with an updated statement of Mission and Objectives. The updated Mission and Objectives include:
The Mission of the Academy is to promote continual improvement in EES [environmental engineering and science] education and practice.
The Objectives of the Academy are to support the Mission by:
a) ensuring the quality of creating pathways for future EES professionals;
b) providing continuing education for all EES professionals;
c) certifying advanced professionals; prove publication recognition of outstanding individuals and practices; and

d) harnessing the technical expertise of our members to advise decision-makers and the public on the use of EES to improve and maintain the environment. [9].
Sixth, in 2023, the United States Department of Labor formally updated the definition of environmental engineering as, “environmental engineers use engineering disciplines in developing solutions to problems of planetary health,” [10].

Within the broader practice of engineering, a review of current literature was considered. For example, the Body of Knowledge of Civil Engineering was originally promulgated in 2004 [11] and regularly updated by the ASCE, including a second version [12] and a third version [13]. The AIChE promulgated the Body of Knowledge for Chemical Engineers in 2015 [14], and the National Society of Professional Engineers promulgated the, “Professional Engineering Body of Knowledge,” in 2013 [15]. More recently, Thomas and co-authors offered a proposed body of knowledge and pedagogy for, “global engineering” [16], and somewhat related efforts have included the emergence of the practice of “peace engineering” [17]. Collectively, these formally adopted as well as proposed bodies of knowledge provide insight into the depth and breadth of engineering practice in a range of areas adjacent to – and in some cases overlapping with – the field of environmental engineering.

The third thematic area that was examined included changes within the adjacent field of environmental science. For example, in January 1999 the Association of Environmental Engineering Professors (AEEP) was renamed the AEESP. This change recognized, “…The debate about whether engineers are real scientists, and whether scientists should be allowed to join engineering departs is an old one in our profession. The fact remains that there have almost always been public health scientists and microbiologist on the Sanitary and Environmental Engineering faculty. The need to have scientists join with engineers, and to break down barriers in categorizing a person as one of the other, is a defining and inherent aspect of our profession,” [18]. About a decade following the renaming of the AEESP, the AAEES formally recognized scientists as part of the broader environmental profession through two important actions. First, in 2012 the AAEES expanded certification to include, “Board Certified Environmental Scientist,” or BCES. Second, in 2013, the American Academy of Environmental Engineers (AAEE) was renamed the AAEES. Again, about a decade following the renaming of the AAEES, ABET formally accredited the first baccalaureate program in, “environmental science and similarly named programs,” using program criteria developed by AAEES. Collectively, the recognition of environmental science with specialty Board Certification, or the BCES by AAEES, as well as the accreditation of degree granting programs by ABET provides strong evidence of the need to clarify both the common attributes as well as unique attributes of environmental engineers as well as environmental scientists. It should be noted that the AAEES has not yet formally promulgated a, “Environmental Science Body of Knowledge,” and future efforts should address this gap in the literature.

In addition to reviewing the existing literature, as *ad hoc* group engaged constituents through a structured survey shared using a purposeful sampling approach. The survey combined both a Likert-scale (i.e., 1 strongly agree to 5 strongly disagree) as well as an invitation to an open-ended response inquiring to the ongoing utility of each of the 18 outcomes included in the EEBOK1. The survey also included an opportunity to comment on the introductory materials in the EEBOK1 as well as to provide suggestions for any additional outcomes that should be

included in EEBOK2. The purposeful sampling approach was employed to provide broad, representative feedback from diverse stakeholders such as practitioners, employers, educators, and others. A full description of the survey and summary of the survey results is included in Appendix E.

Results

The final report prepared by the volunteer task force formed by the Academy in 2018 is provided in Appendix A.

The survey instrument developed by the *ad hoc* group of members of the Academy and the Association that was disseminated to collect feedback in 2024 is provided in Appendix B.

Table 1 provides a summary of the results of the survey performed in 2024. A total of 28 individuals provided responses, which included a Likert-scale on the current validity of each section. A score of 5 indicates that everyone who responded believed that the section was adequate, while a score of 1 indicates that everyone who responded believe that the section was inadequate in its current form.

Table 1. Results of responses to anonymous, online, voluntary survey of the existing EEBOK1 conducted in 2024 (n=28).

OUTCOME	AVERAGE	STD DEV	DESCRIPTION	SUBCATEGORY
Summary	3.5	1.3	Executive Summary	Executive Summary
17	3.8	1.2	Business and public administration	Professional
11	4.0	1.1	Globalization and contemporary issues	Enabling
18	4.0	1.0	Leadership	Professional
10	4.1	0.9	Societal impact and environmental policy	Enabling
16	4.1	1.1	Project management	Professional
3	4.1	1.0	Use of modern engineering tools	Enabling
4	4.1	0.9	In-depth competence	Enabling
7	4.1	1.2	Creative design	Enabling
15	4.1	1.0	Lifelong learning	Professional
6	4.2	1.2	Problem formulation and conceptual analysis	Enabling
8	4.2	1.1	Sustainability	Enabling
9	4.2	0.7	Multi-media breadth and interactions	Enabling
2	4.3	1.0	Design and conduct experiments	Enabling
5	4.3	0.7	Risk, reliability, and uncertainty	Enabling
14	4.3	0.9	Effective communication	Professional
13	4.4	0.8	Professional and ethical responsibility	Professional
12	4.5	0.8	Multi-disciplinary teamwork to solve problems	Professional
1	4.5	0.7	Basic math and science	Foundational

As reported in Table 1, the two areas that were scored the lowest in the survey included the Executive Summary and Outcome 17. Business and Public Administration. After discussing these results, the *ad hoc* group of members of the Academy and the Association suggested a rewrite both of the Executive Summary as well as a rewrite of Outcome 17.

Discussion.

Suggested text for an updated Executive Summary (following the format of the Executive Summary utilized in the most recent version of the Civil Engineering Body of Knowledge) includes:

Executive Summary

Environmental engineering is an exciting and noble profession which applies engineering principles to improve and maintain the environment for the protection of human health, for the protection of nature's beneficial ecosystems, and for environment-related enhancement of the quality of human life. In short, environmental engineers use engineering disciplines in developing solutions to problems of planetary health. The Second Edition of the Environmental Engineering Body of Knowledge (EEBOK2) describes the breadth and the depth of the knowledge, skills, and attitudes, which are demonstrated across the diverse practice areas of environmental engineering at the professional level. The EEBOK2 is inclusive rather than prescriptive. Its intended uses include preparing the future environmental engineer for entry into the practice of environmental engineering. As noted previously, a hallmark of any profession is its specialized work that is grounded in an officially recognized body of knowledge (Ressler 2011). While the practice of environmental engineering may be traced to antiquity, sanitary engineering – or what is now recognized as environmental engineering – was first codified on October 21, 1955, with the publication of a roster of Diplomates of Sanitary Engineering (now known as Board Certified Environmental Engineers). In 2009, the American Academy of Environmental Engineers (now known as the American Academy of Environmental Engineers and Scientists) published the First Edition of the Environmental Engineering Body of Knowledge (EEBOK1). The EEBOK2 builds on the time-tested and proven content provided by the First Edition (AAEE 2009). In addition, the EEBOK2 appreciates the professional partnership among environmental engineers and environmental scientists (e.g., as reflected in the renaming of the American Academy of Environmental Engineers and Scientists), leverages the efforts of the adjacent profession of civil engineering represented by the American Society of Civil Engineers (2004, 2008, 2019), recognizes the work of the National Council of Examiners for Engineering and Surveying (NCEES 2019, 2020), and responds to the report, "Environmental Engineering for the 21st Century: Addressing Grand Challenges," (NASEM 2019).

The EEBOK2 is described by 18 outcomes in three categories as shown in Table ES-1. Each of the 18 outcomes is described by an outcome rubric, which includes the level of achievement that often is obtained by environmental engineers upon completion of a baccalaureate degree in environmental engineering, upon completion of a masters degree or 30 semester credits or equivalent post baccalaureate education, and after four years of professional experience. As originally described in the First Edition, the outcome rubrics in EEBOK2 are based on Bloom's taxonomy of cognitive knowledge (1956). The EEBOKs continues to recognize the diversity of engineering and science backgrounds as a strength of environmental engineering. As such, the EEBOK2 recognizes multiple pathways for fulfilling the level of achievement using four components, including: undergraduate education in environmental engineering, undergraduate education in adjacent disciplines, postgraduate education, and professional experience.

Table ES-1. *Environmental Engineering Body of Knowledge Outcomes.*

Fundamental Outcomes	*Enabling Knowledge and Skills Outcomes*
1. Basic Environmental Math & Sciences (BEMS) Knowledge	*2. Design and Conduct Experiments* *3. Modern Engineering Tools*
Professional Outcomes	*4. In-Depth Competence*
12. Multi-Disciplinary Teamwork *13. Professional and Ethical Responsibility* *14. Effective Communication* *15. Lifelong Learning* *16. Project Management* *17. Decision Making Frameworks* *18. Leadership*	*5. Risk, Reliability, and Uncertainty* *6. Problem Formulation and Conceptual Analysis* *7. Creative Design* *8. Sustainability* *9. Multi-Media Breadth and Interactions* *10. Societal Impact* *11. Contemporary and Global Issues*

The EEBOK2 is the product of the Environmental Engineering Body of Knowledge Task Committee, which had representatives from across the breadth of the environmental engineering profession. The Committee also sought extensive constituent input during the development of the EEBOK2 through, inter alia, a series of quantitative and qualitative surveys. The Committee relied heavily on the constituent survey responses along with the aforementioned resources (ASCE 2004, ASCE 2008, ASCE 2019, NASEM 2019, NCEES 2019, NCEES 2020).

As an aspirational compass for the profession, the EEBOK2 applies to all environmental engineers, regardless of career path or area of practice. Accordingly, it should be of interest to a broad audience, including educators, students, emerging career environmental engineers, professionals who mentor emerging career environmental engineers, experienced engineers, those seeking specialty Board Certification, among others. Not intended as a prescriptive document, the EEBOK2 is meant to be used in concert with other materials to help communicate important aspects of the EEBOK2 that may be most relevant to specific groups, such as students, faculty, emerging career engineers, mentors, and organizational leaders.

References

AAEE (American Academy of Environmental Engineers). 2009. Environmental engineering body of knowledge, 1st Ed. Annapolis, MD: AAEE.

ASCE (American Society of Civil Engineers). 2004. Civil engineering Body of Knowledge for the 21st century: Preparing the civil engineer for the future, 1st Ed. Reston, VA: ASCE.

ASCE (American Society of Civil Engineers). 2008. Civil engineering Body of Knowledge for the 21st century: Preparing the civil engineer for the future, 2nd Ed. Reston, VA: ASCE.

ASCE (American Society of Civil Engineers). 2019. Civil engineering Body of Knowledge for the 21st century: Preparing the civil engineer for the future, 3rd Ed. Reston, VA: ASCE.

Bloom, B. S., M. D. Englehart, E. J. Furst, W. H. Hill, and D. Krathwohl. 1956. Taxonomy of educational objectives, the classification of educational goals. Handbook I: Cognitive domain. New York: Longman.

NASEM (National Academies of Sciences, Engineering, and Medicine). 2019. Environmental engineering for the 21st century: Addressing grand challenges. Washington, DC: The National Academies Press.

NCEES (National Council of Examiners for Engineering and Surveying). 2019. NCEES Principles and Practice of Engineering Examination: Environmental CBT Exam Specifications. Greenville, SC: NCEES. Accessed November 19, 2024. https://ncees.org/wp-content/uploads/2022/09/PE-Env-April-2019_CBT.pdf.

NCEES (National Council of Examiners for Engineering and Surveying). 2020. Fundamentals of Engineering: Environmental CBT Exam Specifications. Greenville, SC: NCEES. Accessed November 19, 2024. https://ncees.org/wp-content/uploads/FE-Environmental-CBT-specs.pdf.

Ressler, S. J. 2011. "Sociology of professions: Applications to the civil engineering 'Raise the Bar' initiative." J. Prof. Issues Eng. Educ. Pract. 137(3): 152−153. Accessed November 19, 2024. https://doi.org/10.1061/(ASCE)EI.1943-5541.0000043.

Improvement to Outcome 17 includes a modification of the outcome as follows: from "Outcome 17: Business and Public Administration" to "Outcome 17: Decision Making Frameworks."

Outcome 17: Decision Making Frameworks

Outcome explanation: *Environmental engineers dealing with private and public organizations must understand decision making frameworks. These may include traditional frameworks such as asset management as well as newer frameworks such as environmental, social, and governance (ESG) investing or broad public policies such as the Agenda for Sustainable Development (commonly known as the United Nation's Sustainable Development Goals).*

Level of Achievement:

At completion of the baccalaureate degree in Environmental Engineering:

- ***List** and **describe** important fundamentals of decision making frameworks related to environmental engineering.*

At completion of the masters degree or 30 semester credits or equivalent post baccalaureate:

- *There are no achievement requirements at this level*

After profession practice with four years experience:

- ***Analyze** problems involving decision making frameworks as they relate to environmental problems.*

***Knowledge Domains:** Humanities/social science, economics and business management.*

As noted in the introduction of EEBOK1, published in 2009, "the EnvE BOK is not intended to be prescriptive, but instead to be directional, forward looking; and more of a compass than a detailed road map," [1]. In support of this open invitation to continually explore improvements in describing the Body of Knowledge employed by environmental engineers, this current article offers suggestions for consideration during any future updates.

Conclusion

Any body of knowledge aspires to describe the complete set of vocabulary, theory, and action, which constitute professional practice as defined by the relevant learned society or professional association [19]. Accordingly, the body of knowledge of the profession of environmental engineering should include both the breadth and the depth of the knowledge, skills, and attitudes, which are demonstrated across the diverse practice of environmental engineering at the professional level, including those who have obtained Board Certification in a subspeciality of environmental engineering (individual identified with the postnominal as BCEE). As described in this article, suggested language to be considered as part of an update to the EEBOK1 is offered both to improve the executive summary as well as to suggest improvements to Outcome 17.

References.

1. AAEE (American Academy of Environmental Engineers). 2009. Environmental engineering body of knowledge, 1st Ed. Annapolis, MD: AAEE.
2. AAEES (American Academy of Environmental Engineers and Scientists), Environmental Engineering Body of Knowledge Update Report. Annapolis, Maryland, 2018.
3. D.B. Oerther, D.A. Chin, V. G. Gude, C. N. Haas, A. A. MacKay, F. Ozis, M. K. M. Paynes, and D. A. Vaccari. "The Academy, the Association, and the Society advancing environmental engineering

training and credentialing." *Environ. Eng. Sci.*, vol. 38, no. 10, pp. 923-926, 2021. [Online] Available: https://doi.org/10.1089/ees.2021.0347.
4. D.B. Oerther, D. A. Chin, and D. A. Vaccari, "Updating the environmental engineering body of knowledge." *J. Environ. Eng.*, vol. 148, no. 2, no. 01821005, 2022. [Online] Available:
5. https://doi.org/10.1061/(ASCE)EE.1943-7870.0001973.
6. D.B. Oerther, D. A. Chin, A. Shaw, D. A. Vaccari, and W. Wert, "Dear WEF, the Academy needs your input to update the environmental engineering body of knowledge." *Wat. Environ. Res.*, vol. 93, no. 12, pp. 2832-2833, 2021. [Online] Available: https://doi.org/10.1002/wer.1647.
7. D.B. Oerther, D. A. Chin, J. E. Tobiason, and D. A. Vaccari, "Updating guidance for environmental engineers." *J. AWWA*, vol. 114, no. 2, pp. 70-71, 2022. [Online] Available: https://doi.org/10.1002/awwa.1870.
8. B. Flynn, "Environmental Sustainability: A New AAEE Certification." *Environmental Engineer*, vol. 46, no. 1, pp. 8-10, 2010
9. NASEM (National Academies of Sciences, Engineering, and Medicine). 2019. Environmental engineering for the 21st century: Addressing grand challenges. Washington, DC: The National Academies Press.
10. AAEES (American Academy of Environmental Engineers and Scientists). 2022. Bylaws of the American Academy of Environmental Engineers and Scientists. Ann Annapolis: AAEES.
11. D.B. Oerther, S. Oerther, and C. A. Peters, "Environmental Engineers Solve Problems of Planetary Health." *Environ. Eng. Sci.*, vol. 41, no. 1, pp. 3-6, 2024. [Online] Available: https://doi.org/10.1089/ees.2023.0301.
12. ASCE (American Society of Civil Engineers). 2004. Civil engineering Body of Knowledge for the 21st century: Preparing the civil engineer for the future, 1st Ed. Reston, VA: ASCE.
13. ASCE (American Society of Civil Engineers). 2008. Civil engineering Body of Knowledge for the 21st century: Preparing the civil engineer for the future, 2nd Ed. Reston, VA: ASCE.
14. ASCE (American Society of Civil Engineers). 2019. Civil engineering Body of Knowledge for the 21st century: Preparing the civil engineer for the future, 3rd Ed. Reston, VA: ASCE.
15. AIChE (American Institute of Chemical Engineers). 2015. Body of knowledge for chemical engineers. New York: AIChE.
16. NSPE (National Society of Professional Engineers). 2013. Professional engineering body of
17. knowledge. Alexandria, VA: NSPE.
18. E. Thomas, C. Salvinelli, J. Harper, A. Javernick-Will, and K. Lindon, "A body of knowledge and pedagogy for global engineering." *IJSLE*, vol. 16, no. 1, pp. 37-57, 2021.
19. R. Jordan, K. Agi, S. Arora, C. G. Christodoulou, E. Schamiloglu, D. Koechner, A. Schuler, K. Howe, A. Bidram, M. Martinez-Ramon, and J. Lehr, "Peace engineering in practice: A case study at the University of New Mexico." *Technol. Forecast. Soc. Change*, vol. 173, no. 12113, 2021.
20. B. Logan, "President's Letter," *AEEP Newsletter*, vol. 33, no. 3, pp. 1, 1998. Washington, DC: AEESP.
21. Ressler, S. J. 2011. "Sociology of professions: Applications to the civil engineering 'Raise the Bar' initiative." J. Prof. Issues Eng. Educ. Pract. 137(3): 152−153. Accessed November 19, 2024. https://doi.org/10.1061/(ASCE)EI.1943-5541.0000043.

Appendix A.

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October 19th 2018

To: **American Academy of Environmental Engineers and Scientists – Leadership**
Association of Environmental Engineering and Science Professors - Leadership

From: **The Environmental Engineering Body of Knowledge (BOK) Phase 1 Taskforce**

Subject: **Phase 1 Recommendation**

The American Academy for Environmental Engineers and Scientists (AAEES) formed a volunteer Taskforce to complete the following Phase 1 Charge over a nine-month period:

> *Evaluate if changes are needed to the 2009 Environmental Engineering BOK, and if necessary, propose a process to prepare the 2019 Environmental Engineering BOK2.*

The Task Force comprised 17 environmental engineering leaders from academia and industry who started their work in February 2018 (Attachment A). They first engaged in an extended reading and discussion period to improve members' understanding of the 2009 BOK along with other relevant documents. Readings included the following:

- 2009 Environmental Engineering BOK
- 2013 NSPE Engineering BOK
- ABET EAC Criterion 3-5 Approved Revisions for the 2019-20 accreditation cycle
- Commentary on the ABET Program Criteria for Environmental Engineering Programs
- Final Workshop Series Report: Redefining Environmental Engineering and Science in the 21st Century, sponsored by NSF and AEESP
- [Several Task Force members also explored the AIChE and ASCE BOKs; some of the Task Force members are involved in the effort to update ASCE's BOK3]

Throughout the discussions, the Task Force explored the 2009 BOK from both academic and practice perspectives while focusing on Section VII in the 2009 BOK: "*where do we go from here*." Based on this exploration, the Task Force identified several potential opportunities to improve the 2009 BOK.

The Task Force obtained feedback about this initial set of improvement opportunities from the broader environmental engineering community including the AAEES Education Committee (May 2018 conference call), the AEESP Environmental Engineering Chairs Meeting (May 2018 webinar), and the ASEE Environmental Engineering Division Annual Meeting (June 2018 conference). Further, the Task Force electronically surveyed the membership of these organizations with 151 responses that included an approximate split of 30% practitioners and 70% academics. Within academics, the majority who responded are senior, retired, and/or administrative faculty, and over 60% are at public institutions. The academic respondents represent a range of Program sizes in terms of graduating seniors (10 to 60). Over 80% of all respondents are licensed professional engineers and almost 30% are ABET program

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evaluators. Of the Programs represented by the survey, 70% have an ABET accredited environmental engineering program. Over 60% of the Programs represented were created before 1997. [The detailed findings can be found in Attachment B.] The Task Force did not disaggregate the data by subpopulations and based its recommendations on the combined set of feedback.

The Phase 1 Task Force concluded that the 2009 BOK should be revised using the feedback from the Phase 1 effort as the primary guide. The revisions needed fall into five main categories as follows:

- Clarify what the BOK is, how it compares with other guiding frameworks, and how it can be used primarily in terms of curricular development and improvement.
- Update the BOK (including metrics) to reflect the state of field now and into the future; in particular, delineate the role of the environmental engineer as part of a multi-disciplinary team that includes many professionals.
- Delineate the competencies required at each stage of one's career versus those competencies that are choices with a goal of ensuring that the BOK allows Programs to be innovative in terms of curricular development for future professionals.
- Add attitudes, in addition to knowledge and skills, to the BOK competencies beneficial for each stage of one's career (and indicate whether each is competency is required or optional).
- Simplify and streamline the document while avoiding repetition with other complementary BOKs.

We recommend the following Phase 2 process to prepare the 2019 BOK for Environmental Engineering along with associated efforts to improve its visibility and use.

1. Obtain funding from NSF and AAEES to facilitate the revision process. At a minimum, funding should include support for a dedicated person (part-time staff, student, or faculty) to prepare the initial drafts, at least one Phase 2 Task Force meeting, and travel to environmental engineering conferences/meetings.
2. Form the Phase 2 Task Force representing a subset of the Phase 1 Task Force members who are committed to providing feedback and guidance to the person preparing the initial drafts.
3. Present the second draft of the 2019 BOK2 at key environmental engineering meetings and conferences to obtain further feedback and publicize the effort.
4. Finalize the 2019 BOK2 and develop a plan to actively and continuously advertise it to the variety of stakeholders.
5. Implement a clearing house for examples of how to use the BOK2 for curricular enhancement.
6. Conduct BOK reviews and updates on a more frequent basis (to be determined) via a standing committee on the AAEES Board (or jointly with the AEESP Board). That committee could also serve as steward for the clearing house. The overall philosophy should be that the BOK2 is a living document that supports the environmental engineering community.

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ATTACHMENT A: Phase 1 Task Force Membership

Last Name	First Name	Organization	Public/Private	Specialty
MacKay	Allison	The Ohio State University	Public	Co-chair
Jones	Sharon	University of Portland	Private	Co-chair
Bielefeldt	Angie	University of Colorado	Public	ASCE BOK Committee/pedagogy
Cotruvo	Joseph	Joseph Cotruvo and Associates	Private	drinking water quality
Curran	Pat	Pat Curran + Associates	Private	civil/environmental
Daigger	Glen	JACOBS ch2m & University of Michigan	Private/Public	water quality/ education-practice interface/ NAE ethics
Griffin	Rob	Rice University	Private	air quality
Haas	Chuck	Drexel University	Private	2009 BOK/drinking water
Kavanaugh	Mike	Geosyntec Consultants	Private	environmental remediation
Otim	Ochan	City of Los Angeles Bureau of Sanitation	Public	environmental monitoring
Shaw	Andrew	Black & Veatch	Private	sustainability, water quality
Sillan	Randy	AECOM	Private	hazardous waste
Stubbs	John	Air Force Institute of Technology	Specialty	accredited masters/systems
Tansel	Berrin	Florida International University	Public	water treatment/ hazardous waste/ industrial waste/
Theis	Tom	University of Illinois Chicago	Public	sustainability
Vadas	Tim	University of Connecticut	Public	ecological
Zhang	Qiong (Jane)	University of South Florida	Public	sustainable development

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ATTACHMENT B: Detailed Results of the Phase 1 Review

Stakeholder Familiarity with the 2009 BOK (based on an electronic survey)

- Only a few (11%) stakeholders are very familiar and use the 2009 BOK with 32% stating they never heard of it and approximately 56% stating they heard of it or have read parts of it.
- For those who have some level of familiarity, 27% have used it to inform departmental curricula discussions. Much smaller percentages have intentionally used the 2009 BOK for curriculum change. 27% of those familiar with the BOK stated they had never used it.
- Despite the overall lack of use, 66% of those who have some familiarity with the 2009 BOK feel it needs to be updated. Only a small percentage of stakeholders with some familiarity (3%) stated that a BOK is not needed.
- For those who suggest an update is needed, the main reasons are for corrections, to provide more clarity, and to include several missing but important aspects.
- Some of the stakeholders suggested additional reasons for an update including the importance of regular reviews, that the document is too verbose, the field is constantly changing, and the ABET student outcomes have changed.

Strengths of the 2009 BOK

Survey respondents agreed the below list represents the 2009 BOK strengths:

- Provides a comprehensive descriptor of the field including employment sectors and technical competencies.
- Captures the reason for becoming an environmental engineer and the journey over one's career.
- Provides a roadmap for competency development of practitioners through undergraduate, graduate, and professional training regardless of sub discipline. This roadmap emphasizes that environmental engineers may follow multiple education and career pathways and that this flexibility has been, is, and will continue to be key.
- Provides resources for guiding knowledge, skills, and outcomes at the undergraduate and graduate levels.
- While the Task Force and some survey respondents noted that structuring the BOK using the ABET framework provides those universities considering an ABET-accredited Environmental Engineering program with a useful guide, some survey respondents suggested that this level of specificity is a weakness.

The Task Force discussions led the group to conclude that primary audience for the BOK is the academic community and that practitioners trust higher education to prepare graduates for entry-level positions.

Limitations of the 2009 BOK (based on electronic survey)

- Lacks specific guidance about curricular content (one person noted this could be a strength as well)
- Purpose of the document is not clearly articulated

- Lacks distinction between what are core competencies versus optional skills to allow programs flexibility in curriculum design (one person noted that BOK should stick to core competencies as the list of professional outcomes is too big)
- Individual comments included:
  - Weak connection to employment sectors
  - Too prescriptive
  - Too daunting to digest
  - Separate one for engineers and one for scientists
  - Humanities minimized
  - Emotional intelligence could be added
  - Technology is expanding rapidly
  - Line up outcomes with ABET general criteria and don't add more
  - Need to be able to directly download from AAEES website (not store)

What Primarily Influences Environmental Engineering Curriculum Development (based on electronic survey)

- ABET Program criteria is the primary influence
- Local/regional employer needs and the BOK have some influence
- Other influences noted:
  - NCEES FE Exam
  - Continuous improvement with stakeholder feedback
  - International standards
  - Faculty interests including their research interests
  - ABET general criteria

Improvement Opportunities for the 2009 BOK

Overall, at least 93 of the 151 survey respondents either agreed or strongly agreed with areas of focus for improvements to the BOK that the Task Force recommended. The list is organized below according to the priority from survey respondents.

1. Clarify language around clear purpose with statement of why BOK is needed and who it is for.
2. Update the current emphasis on pollution prevention and mitigation (reactive and anticipatory) to sustainable design (high integration).
3. Expand to include environmental engineering vocabulary, context, and definitions.
4. Revise to emphasize flexibility so that academic programs can innovate while embracing the diversity of the profession. E.g., provide guidance on the minimum number of technical areas required at the entry-level undergraduate versus graduate levels to avoid rigidity with the ABET Program Criteria.
5. Emphasize the multiple pathways to achieve the BOK throughout the document.
6. Include language to distinguish between core competencies and contributions that environmental engineers make to other related problems/disciplines.

7. Expand to include additional themes such as land use/control, use of geographic data, resilient and interdependent infrastructure, complex systems, and systems thinking.
8. Address the role of environmental/social science and scientists as part of the environmental engineering profession.
9. Reference the NSPE BOK (not repeat) and provide details for only what is needed for the environmental engineering discipline with an emphasis on simplicity and flexibility.
10. Include some guidance about implementation of the BOK for curriculum change or development.
11. Initiate a complementary effort to develop a clearinghouse for ideas of implementing the BOK for curriculum changes and curriculum development (e.g., case studies, innovative approaches).
12. Using the NSPE BOK as a model, include attitudes in addition to knowledge and skills since competency goes beyond what you know and what you can do to how and why you do it.
13. Replace the historic rationale for a BOK with a narrative about the strength of the discipline as evidenced by a significant and continuous growth in ABET accredited programs over the last 20 years.
14. Revise to reflect updated ABET Criteria 3 and 5.

Other Critical Suggestions for Improvements Based on Survey:

- Delineate what is a dominant core competency versus valuable competencies, and which additions should be at the graduate level. Breadth is important but some areas are more important given industry trends.
- Delineate an environmental engineer versus the many related disciplines. Emphasize that they work together to solve problems but delineate specific for the engineers. Discuss employment sectors and workforce needs in each sector (e.g., ENR revenue).
- Include more discussion about design process.
- Clarify how BOK fits with ABET criteria and perhaps the FE Exam while discussing how programs can be innovative within those constraints.
- Include and emphasize sustainability.
- Discuss CAD, GIS, GPS coverage.
- Discuss systems approach, tools, etc.
- BOK should be reviewed on a regular cycle to ensure it is forward thinking.

The survey responses demonstrate that there is a clear difference of opinion as to whether the BOK should be a cookbook or a holistic document.

Appendix B.

From: [redacted]
Subject: ACTION REQUESTED (before August 12): Input sought on refresh of Environmental Engineering Body of Knowledge document by AAEES
Date: July 29, 2024 at 11:33 AM
To: [redacted]

(Apologies to those who may have received this as part of a different stakeholder group; you don't need to complete this survey twice; thanks.)

Dear Colleagues who are Members of the National Academy of Engineering and the American Academy of Environmental Engineers and Scientists,

We are emailing to solicit your expert input as the Academy works to refresh the Environmental Engineering Body of Knowledge (BoK).

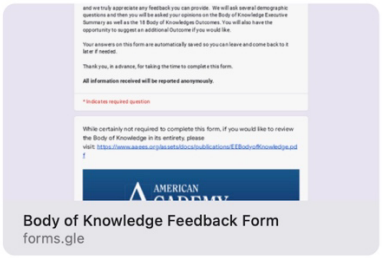
In 2009, the Academy published our original BoK. The BoK is intended as a "living document", which means that periodically we review and update the content.
The BoK was last reviewed by a working group in 2018.

In 2024, the Academy is leading an effort - in collaboration with the Association of Environmental Engineering and Science Professors (AEESP) and others - to review and refresh the BoK (where appropriate).

Already, we solicited input from the following stakeholder groups, including:
1) Those who previously participated in the 2018 report;
2) Current members of the AEESP Education Committee;
3) Current members of the Academy Expertise and Exam Committee – who share responsibility for defining the content and creating written and oral exams for specialty Board Certification;
4) Current members of the Academy Excellence in Environmental Engineering and Science annual awards competition – who share responsibility for identifying the "best of the best" in practice and research;
5) Current ABET Program Evaluators – who visit university programs as part of the accreditation process; and
6) Current Environmental Engineering Program Directors – as identified through a shared list maintained by the Academy and AEESP.

As members both of the National Academy of Engineering and the American Academy of Environmental Engineers and Scientists, we are writing to you today to invite your expert input as part of our effort.

BEFORE MONDAY AUGUST 12, 2024, we would request that you follow the link and complete the google form survey available at:



The survey requests a few pieces of demographic information, which we will publish in aggregate (yes, we will publish the complete list of names who participate in the survey, but we will not attribute any responses to any name).

The survey includes the background on the BoK from the original 2009 publication (available in full, online at: [redacted]. There is NO NEED for you to read the entire BoK, but you are welcomed to read as much (or as little) as you wish.

The survey includes the current 18 (eighteen) outcomes – from basic math and science, to professional leadership, and everything in between. You are asked to comment on EACH of these 18 outcomes – is the current language adequate, should something be adjusted, etc.

The survey includes an open ended section where you are invited to indicate OTHER outcomes that should be included. For example, "climate resilience" and "social justice" are not explicit in the 2009 version (although "sustainability" and "societal impacts" and "contemporary issues" may be viewed as covering the general nature of these emerging topics without specifically enumerating details of particular items).

The goal of the BoK is to "strike a balance" between "too detailed" and "too generic" (i.e., yes, environmental engineers should be aware of emerging pollutants, but perhaps listing CO2, PFAS, or antibiotics specifically may be "too detailed"…)

Also, the goal of the BoK is to capture the "breadth and depth" of environmental engineering practice, research, and teaching. It is NOT intended to be a prescriptive list of "the only things that can be done", nor is it to be viewed as a list of requirements (i.e., "the things that must be done"). Some educational programs may cover portions, some practitioners may be experienced with portions – the goal is to cover the "waterfront" of the profession.

If you run into any difficulties, I would be pleased to help!