New Civil Engineering Program Criteria: How the Sausage is Being Made

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Abstract

The American Society of Civil Engineers organized the Civil Engineering Program Criteria Task Committee in October 2012 whose charge is to determine if the current ABET Civil Engineering Program Criteria (CEPC) should be changed to reflect one or more of the 24 outcomes of the second edition of the *Civil Engineering Body of Knowledge* published in 2008. After over a year of conference calls and face to face meetings, the committee has drafted and disseminated a proposed CEPC. This paper chronicles the development of the proposed criteria by sharing a review of the literature, the committee's methodology and process, the key issues that emerged, the resulting proposed criteria, and the future work of the committee.

Introduction

The American Society of Civil Engineers (ASCE) established the Civil Engineering Program Criteria Task Committee (CEPCTC) in October 2012. The charge of the CEPCTC is to determine if the current ABET Civil Engineering Program Criteria (CEPC) should be changed to reflect one or more of the 24 outcomes of *Second Edition of the Civil Engineering Body of Knowledge for the 21st Century* (BOK2) published in 2008. After over a year of bi-weekly conference calls, careful study, and two face-to-face meetings, the CEPCTC voted to recommend the following Proposed Civil Engineering Program Criteria:

PROGRAM CRITERIA FOR CIVIL AND SIMILARLY
NAMED ENGINEERING PROGRAMS
Lead Society: American Society of Civil Engineers

These program criteria apply to engineering programs including "civil" and similar modifiers in their titles.

1. Curriculum

The program must prepare graduates to apply knowledge of mathematics through differential equations, calculus-based physics, chemistry, and at least one additional area of natural science; apply principles of probability and statistics to solve problems containing uncertainty; conduct experiments in more than one technical area of civil engineering and analyze and interpret the resulting data; analyze and solve well-defined problems in at least four technical areas appropriate to civil engineering; design a system, component, or process in more than one civil engineering context; apply principles of sustainability in design; apply principles of project management; explain basic concepts in business, public policy, and leadership; analyze issues in professional ethics; and explain the importance of professional licensure.

2. Faculty

The program must demonstrate that faculty teaching courses that are primarily design in content are qualified to teach the subject matter by virtue of professional licensure, or by education and design experience. The program must demonstrate that it is not critically dependent on one individual.

This paper chronicles the development of the proposed criteria by sharing a review of the literature, the committee's methodology and process, the key issues that emerged, the resulting proposed criteria, and the future work of the committee.

Composition of the Committee

The CEPCTC is comprised of a mix of distinguished civil engineering practitioners and experienced academics with considerable experience in the accreditation process. The committee was rounded out with ASCE staff members who are knowledgeable about education and the accreditation change and approval process.

Task Committee Members:

• **Rich Anderson (Chair)**: Somat Engineering, Inc.; Past-President of ABET; past Chair of the BOK2 Committee.
• **Dave Binning:** Applied Engineering Management Corporation; member of ABET Engineering Accreditation Council (EAC), and active in ASCE educational committees.
• **George Blandford:** CE Department Chair at University of Kentucky, past Chair of the Department Head Coordinating Council (DHCC), and active in ASCE educational committees.
• **Phil Borrowman:** Retired from Hanson Professional Services Inc.; Past-President of ABET and retired consulting engineer.
• **Donald Carpenter:** Professor of Civil Engineering and Past Director of Assessment, Lawrence Technological University with extensive experience in preparing ABET Self Studies.
• **Allen Estes:** Architectural Engineering Department Chair at California Polytechnic State University; experienced ABET PEV and active in ASCE Committee on Education and DHCC.
• **Jeff Evans:** Immediate Past CE Chair at Bucknell University; active in ASCE "Raise the Bar" committees.
• **Ken Fridley:** CE Chair at the University of Alabama; active in ASCE educational committees, past Vice-Chair of the BOK2 Committee, and prepared five ABET self-studies.
• **Tom Lenox:** Member of ABET Board of Directors; ASCE Executive VP Emeritus -- retired from ASCE staff after supporting various educational/professional initiatives.
• **Carolyn Merry:** Professor Emeritus, Past CE Department Chair, The Ohio State University, and past Chair of the DHCC.
• **Paul Mlakar:** U.S. Army Corps of Engineers, experienced ABET PEV, and member of ABET/EAC.
• **Ellen Stevens:** Consulting engineer, ABET/EAC PEV, and active in ASCE educational committees.
• **Jim O'Brien:** Ex-officio, ASCE staff, Managing Director, Professional & Educational Activities.
• **Ping Wei:** Staff contact, ASCE staff, Director, Educational Activities.
• **Corresponding members** of the CECPTC include Angela Bielefeldt, University of Colorado – Boulder; Joseph Hanus, United States Military Academy; Kenneth Lamb, California State Polytechnic University – Pomona; Daniel Lynch, Dartmouth College; Dennis Truax, Mississippi State University; David Vaccari, Stevens Institute of Technology; and Ronald Welch, The Citadel.

Background and Review of the Literature

Recognizing that the traditional four-year baccalaureate degree was becoming increasingly inadequate as formal academic preparation for the professional practice of civil engineering, ASCE adopted Policy Statement 465 -- Academic Prerequisites for Licensure and Professional Practice -- which supports the concept of the master's degree as "the First Professional Degree for the practice of civil engineering."[1] As work on implementing Policy 465 progressed under the leadership of the Committee on Academic Prerequisites for Professional Practice (CAP^3), it was realized that specific academic degree requirements should derive from a profession's body of knowledge (BOK) and what is required to attain it. ASCE completed an effort to formally define the Civil Engineering BOK in January 2004 when it published *Civil Engineering Body of Knowledge for the 21st Century,* which described the knowledge, skills, and attitudes necessary for entry into the practice of civil engineering at the professional level.[2] This first edition of the Civil Engineering BOK (BOK1) defined 15 outcomes with specified levels of achievement that were to be obtained through formal education and pre-licensure professional practice experience. The terms recognition, understanding, and ability were used to communicate the levels of achievement. The first 11 outcomes mirrored the 3 a-k student outcomes in the ABET general criteria[3] and the remaining four outcomes dealt with specialized technical knowledge, management, business/public policy, and leadership.

The Accreditation Committee of CAP^3 was established in January 2004 and charged with revising the then-current CEPC[4] to make it more consistent with BOK1. The then-current CEPC was commonly viewed as overly prescriptive containing requirements such as "procurement of work, bidding versus quality-based selection processes, how the design professionals and the construction professions interact to construct a project." The committee aligned every BOK1 outcome with a provision in either the ABET general criteria or the CEPC. The first 11 outcomes aligned one-to-one with the ABET 3 a-k general criteria student outcomes with supplementary links to the CEPC; the specialized knowledge outcome aligned with the master's program criterion; and the remaining three outcomes aligned with new provisions in the CEPC. To make the CEPC less prescriptive, the requirement for probability and statistics was removed, but a requirement for an additional area of science beyond chemistry and physics was added. The then-proposed CEPC was submitted to the ABET Engineering Accreditation Commission (EAC) in June 2006. These criteria were approved by the ABET Board of Directors in October 2007 and were implemented for accreditation visits starting in the fall of 2008. These criteria[3] are currently in effect, are shown in Appendix B, and are referred to as the existing criteria throughout this paper.

The second edition of *The Civil Engineering Body of Knowledge for the 21st Century,* (BOK2)[5] was published in February 2008. Three inspirational, forward-thinking documents affected BOK2. In 2004, the National Academy of Engineering (NAE) published *The Engineer of 2020*[10] which offered a vision for the engineering profession. The document cited the need for strong analytical skills, practical ingenuity, communication skills, business and management knowledge, leadership, high ethical standards, professionalism, dynamism, agility, resilience, flexibility, and lifelong learning. NAE furthered these ideas in 2005 with the publication of *Educating the Engineer of 2020*. This work called upon engineering leaders to "adapt to new trends and provide them (students) with the tools needed for the world as it will be, not as it is

today." While acknowledging that certain basics of engineering will not change, the NAE document emphasized the explosion of knowledge, the global economy, and the way engineers will work in the future. A 2007 successor document was ASCE's *Vision for Civil Engineering in 2025*, which defined the role of civil engineers as planners, designers, constructors, and operators of society's economic and social engine, in the built environment; stewards of the natural environment and its resources; innovators and integrators of ideas and technology across the public, private, and academic sectors; managers of risk and uncertainty caused by natural events, accidents, and other threats; and leaders in discussions and decisions shaping public environmental and infrastructure policy.[11]

The BOK2 increased the number of outcomes from 15 to 24 and there was no longer a one-to-one correspondence with the ABET 3 a-k student outcomes. While several of the outcomes (risk and uncertainty, historical perspectives, sustainability) were new, many of the BOK2 outcomes split the BOK1 outcomes into component parts for clarity. Bloom's taxonomy was used in BOK2 to replace the terms recognition, understanding, and ability used in BOK1 to describe the desired level of outcome attainment. Bloom's taxonomy relies on action verbs in the outcome statements to classify the cognitive level into one of six distinct hierarchical categories: knowledge, comprehension, application, analysis, synthesis, and evaluation.[6] The BOK specified the appropriate level to be attained for each outcome by the completion of the baccalaureate education, master's-level education, and pre-licensure professional experience. Appendix A lists the 24 BOK2 outcomes along with the outcome statement to be attained at the undergraduate level.

Recognizing that the BOK2 outcomes might eventually influence the ABET accreditation criteria, Ressler[7] proposed a methodology for doing this. Through a comparison of the BOK2 outcomes and the existing BOK1-compliant CEPC, Ressler identifies specific criteria changes and scores them on both importance and feasibility. The importance and feasibility scores were used to create a prioritized list of potential changes that could then be evaluated. This paper was important to the CEPCTC because it focused on both the methodology and suggested potential changes.

Ressler[8,9] reported the need for long-term synchronization of the published BOK and its associated accreditation criteria. In 2011, CAP^3 formed a special task committee to develop a strategic plan for long-term management of change. The principal objective of the task committee's work was to propose a systematic and predictable process for continuous change to both the BOK and accreditation criteria. The task committee proposed an eight-year repeatable cycle that "allows time to formulate and publish a new edition of the Civil Engineering BOK and to formulate, publish, gain approval of, and implement new ABET program criteria." The proposal recognizes the six-year accreditation cycle and ensures that the same CE programs are not always testing the new accreditation criteria. The task committee's plan was approved by CAP^3 in February 2012. The CEPCTC is following the timeline proposed in these articles with the expectation that a revised version of the CEPC will go into effect in September 2016, BOK3 will be published in March 2019, and the follow-on iteration of the CEPC can be expected in September 2024.

Methodology

The CEPCTC attempted to approach the task in an organized and systematic manner taking the following steps:

- **Orientation:** The committee was provided with the available literature, the committee charge, and introductory guidance. Several department heads of civil engineering (CE) programs that have already made their programs BOK2-compliant discussed the specific curriculum changes, implications, impacts and challenges of this process.

- **Outcome Analysis:** The BOK2 is expressed in terms of 24 outcomes and uses Bloom's Taxonomy to define the desired level of attainment. Committee members individually volunteered to analyze and create a report on the specific outcomes. Each report examined and compared a specific BOK2 outcome with the current EAC/ABET criteria (baccalaureate-level general criteria and civil engineering program criteria). Each author identified the change that would be necessary to the CEPC to make it "fully-BOK2-compliant." Each author assessed whether such compliance was reasonable and attainable given the real world constraints faced by civil engineering programs and drafted a rationale for any recommended change (or no change). In many cases, the "fully–BOK2-compliant" language and outcome report author's recommendation were very different. The CEPCTC reviewed all 24 outcome reports during the bi-weekly telephone conferences conducted between April 9, 2013 and October 15, 2013. The committee did not attempt to reach consensus at this point. The respective author's findings formed a basis for discussion and a means to identify the most contentious issues and where the major changes to the program criteria might come. The committee discussion raised additional issues and caused several authors to revise content or provide addenda to their reports.

- **Synthesis and Prioritization:** Once each outcome had been discussed, the committee prepared for a face-to-face committee meeting in Chicago. The committee identified eight outcomes from BOK2 for which the EAC/ABET criteria were already considered to be "fully-BOK2-compliant" – and could be eliminated from further consideration:

    - #1-Mathematics
    - #4-Social Sciences
    - #9-Design
    - #15-Technical Specialization
    - #16-Communication
    - #17-Public Policy
    - #21-Teamwork
    - #23-Life-long Learning

    For the remaining outcomes, each committee member and corresponding member was asked to prioritize each proposed change to the CEPC in terms of both "importance" and "feasibility" to make it more BOK2-compliant.

The "Importance" rating provided a numerical score on a three-point scale, based on the Ressler[7] rubric:

- Importance=1 – The criteria change would directly enhance public safety or would promote the long-term attainment of ASCE's Vision 2025.
- Importance=2 – The criteria change would promote attainment of the BOK in curricular areas typically not addressed in current civil engineering programs.
- Importance=3 – All other circumstances, to include adjustments to the specified level of achievement and curricular areas that are already addressed in most current civil engineering programs.

The "Feasibility" rating also provided a numerical score on a three-point scale, based on the Ressler[7] rubric:

- Feasibility=1 – The criteria change is minor, such that a broad consensus in favor of the change is readily attainable. Examples include simple administrative issues, clarifications, and changes involving curricular content that is already present in most curricula.
- Feasibility=2 – The criteria change is substantive, but a relatively broad consensus on the need for change is attainable.
- Feasibility=3 – The criteria change is substantive, and a broad consensus on the need for change will be difficult to achieve.

Appendix A shows those outcomes not previously eliminated, the Bloom's taxonomy level of attainment prescribed at the baccalaureate level by the BOK2, and the CEPC change that would make the criteria BOK2-compliant.

- **Feedback Solicitation:** Recognizing that revising the CEPC produces an important document, particularly for those academic programs that must implement the criteria to receive accreditation, the committee sought feedback from those constituents throughout the process. The CEPCTC Chair sent an email to the ASCE department head list-serve on April 16, 2013 introducing the charge of the committee, providing the background information and asking for input to two questions:

    - Is there any part of the current CE program criteria where compliance has been particularly difficult? Can you offer specific information on why it has been difficult and what you would change to make it better?
    - Is there anything missing from the current criteria that you would like to see in this next iteration?

  The CE department heads held their annual conference in Las Vegas on June 9-11, 2013. The CEPCTC created information sheets describing its charge and sought department head feedback in two separate presentations. During the ASCE Education Committee Weekend in St. Louis from Sept 27-28, 2013, the CEPCTC briefed a joint meeting of the ASCE Department Head Coordinating Council and the ASCE Committee on

Accreditation and solicited their feedback. The feedback received was considered throughout the CEPCTC deliberations.

- **Draft Criteria:** The CEPCTC conducted a two-day face-to-face meeting on October 19-20, 2013 in Chicago. Using all prior analyses and reports, the committee engaged in an all-encompassing and exhaustive discussion of all possible changes to the CEPC. The final product was an initial draft of the proposed Civil Engineering Program Criteria. The road to consensus started with a question: To what extent does the typical baccalaureate-level civil engineering program have room for more accreditation requirements given the credit-hour constraints on civil engineering programs around the country? Committee member opinions ranged from the current curriculum being full already to there is still room for seven to eight additional substantive accreditation requirements. The most common response was there is still room for three to four additional substantive accreditation requirements. This discussion provided a reference point later in the meeting when tough decisions were made on what could reasonably be included in the new criteria. The importance and feasibility ratings discussed earlier framed the order and results of the discussion as each outcome was discussed in detail and voted upon. Appendix A shows the feasibility ratings and the prioritized importance rankings (based on importance ratings) for each outcome under discussion. Several outcomes were particularly contentious and required a second round of discussion until a general consensus was achieved. The specific issues are reported in the next section. With each individual outcome decided, the collective results were combined into draft criteria. The committee debated the wording, the flow, and the order of the new criteria. The committee voted on and unanimously passed the initial draft. After taking two weeks to reflect and to give committee members not in attendance the opportunity to provide input, the CEPCTC made several minor changes and voted to approve the proposed criteria cited at the beginning of this paper.

- **Communication Plan:** The CEPCTC developed a communications sub-committee to provide information to constituents and solicit their feedback. The sub-committee identifies 25 stakeholder groups ranging from CE Department Heads and ABET Program Evaluators to the ASCE Regional Governors and the ASCE Committee on Education. Each constituent was assigned one of four possible priority ratings based on their level of involvement:

    - 1 = high priority and to engage as soon as possible and continuously in December, February, March, and April;
    - 1.5 = high priority for engagement but requires less frequent communication but targeted attention from January to June 2014;
    - 2 = medium priority for engagement in February and April; and
    - 3 = lower priority providing access to CEPC information through web page articles and, maybe, social media, but not directly.

The plan targets communication to constituents based on their priority assignment. The priority 1 constituents received an email message on December 20, 2013 explaining the proposed CEPC. The email included the proposed program criteria, an information sheet, a justification document, and a list of frequently asked questions. Feedback is being solicited from all constituents, and a

means of responding back and consolidating the feedback has been established. A website (http://www.asce.org/ceprogramcriteria/) has been initiated to provide more information. A detailed schedule of email solicitations, personal briefings, public appearances, and committee meetings have been established through the anticipated implementation date of the proposed CEPC by ABET for the 2016-2017 accreditation cycle.

Major Issues

The results of the CEPCTC efforts are best shown in the comparison of the existing CEPC to the proposed CEPC shown in Appendix B. A brief justification for each change is shown in Appendix C. The major issues encountered in developing these criteria are discussed in the next four subsections of this paper. The subsections include (1) the changes that were include in the proposed criteria, (2) the elements of the BOK2 undergraduate outcomes that were not included, (3) the order of presentation of the proposed criteria, and (4) the general issues affecting the process.

Changes to the CEPC: The changes to the CEPC mostly mirror the exact language of the BOK2 outcomes specified for the undergraduate level. Those BOK2 outcomes that resulted in changes were deemed to be the most important outcomes. A major issue was whether there was room in existing CE programs to accommodate these changes. For these outcomes, the committee decided that there was room.

- **Basic versus Natural Science:** Some of the most detailed discussion revolved around a single word. The existing CEPC requires students to apply knowledge of calculus-based physics, chemistry, and at least one additional area of *basic* science. The ABET general criterion 5a uses the term *basic* sciences and defines them as biological, chemical, and physical sciences. The BOK2 Outcome 2 and the proposed CEPC replace the term *basic* science with *natural* science. At issue was why use a different term from the established ABET general criteria that is likely to cause confusion and demand an explanation. The BOK2 states that undergraduates should be able to solve problems in chemistry, physics and one additional area of the natural sciences. While BOK II never explicitly defines natural science, it can be inferred from reading that the definition includes physics, chemistry and "natural science disciplines as biology, ecology, geology/geomorphology, et cetera." This is a broader definition than the one offered for basic science in the general criteria. The broader definition is chosen to offer civil engineering programs a wider variety of choice and flexibility in the extra area of science. A cursory review of the literature indicated that natural science was the more correct term, but it means an explanation will be required in next version of the "Commentary" for civil engineering programs – a document that ASCE has traditionally published to explain terms used in the CEPC.

- **Probability & Statistics:** The proposed CEPC requires graduates to apply principles of probability and statistics to solve problems containing uncertainty, which identically mirrors the language in Outcome 12 of the BOK2. Earlier editions of the CEPC explicitly required mathematics through differential equations and probability and statistics. That requirement was eliminated in the existing CEPC, but the issue was

whether to resurrect the requirement. Adding the probability and statistics back into the math requirements might imply that a separate course on that topic was needed. Risk and uncertainty are inherently probabilistic concepts and the application level in those areas cannot be reached without some understanding and inclusion of probability and statistics. The CEPCTC believes that an entire course is not necessarily required and, in times of constrained curricula, there are conceivably more efficient ways to meet this outcome without an entire course.

- **Civil Engineering Experiments:** The existing CEPC requires students to conduct civil engineering experiments in only *one* area of civil engineering. The proposed CEPC would require students to conduct experiments in *more than one* technical area of civil engineering and analyze and interpret the resulting data. BOK2 Outcome 7 states that undergraduates should be able to "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 technical area of civil engineering." Adding an experimental breadth requirement to the criteria recognizes (1) the apparent reduction in high school and other experimental experiences of students entering engineering and (2) the trends in higher education to reduce laboratory experiences in curricula. The CEPCTC believes that it is critical that future civil engineers have a strong physical understanding of the materials and systems they will design and manage.

- **Technical Breadth:** The existing CEPC only require students to *apply* knowledge of four technical areas appropriate to civil engineering. The proposed CEPC require that students *analyze and solve well-defined problems* in at least four technical areas appropriate to civil engineering. The change represents a higher cognitive level in Bloom's taxonomy. The significance of this change is minor, if at all. The requirement to apply knowledge is the ability to use learned material in new and concrete situations. This may include the application of such things as rules, methods, concepts, principles, laws, and theories. Analysis refers to the ability to break down material into its component parts so that its organizational structure may be understood. This may include the identification of parts, analysis of the relationship between parts, and recognition of the organizational principles involved. Analysis is a higher cognitive level than application because it requires an understanding of both the content and the structural form of the material.[5,6] Practically speaking, the task committee could not quantify how civil engineering programs would have to change their curricula if they are already meeting the existing program criteria. Said another way, this proposed change is primarily administrative – matching the language of the CEPC with BOK2.

- **Sustainability:** The proposed CEPC explicitly require graduates to apply principles of sustainability in design in support of BOK2 Outcome 10 which requires graduates to "apply the principles of sustainability to the design of traditional and emergent engineering systems." Sustainability is already included in Criterion 3(c) of the ABET general criteria as one of the factors to be included in the design of a system, component or process. The issue was why the general criteria were not sufficient. The sustainability outcome was rated as being very important by the CEPCTC. ASCE is a recognized leader in this advancing area. Criterion 3(c) of the general criteria lists "sustainability" as

one of eight constraints that should be considered in a design. However, these eight constraints are preceded by the words "such as" – commonly interpreted by ABET evaluators as meaning "at least one." As such, the existing provision of the general criteria lacks the strength to ensure that all civil engineering students can apply the principles of sustainability.

- **Management versus Project Management:** The existing program criteria require that students *explain* the principles of *management*. The proposed CE criteria require students to *apply* principles of *project management*. The proposed requirement is a higher level of attainment in a narrower area. The most important rationale is that BOK2 recommends that undergraduate students develop solutions to well-defined project management problems. Some examples of project management opportunities in the undergraduate program include design teams for course assignments, capstone design projects, and undergraduate research. These opportunities exist in all of the sub-disciplines of civil engineering. As such, the CEPC does not imply that a specific sub-discipline (e.g., construction management) must be covered.

- **Ethics:** The proposed CEPC requires students to *analyze* issues in professional ethics. Criterion 3(f) of the ABET general criteria requires an *understanding* of professional and ethical responsibility. The issue was why the general criteria were not sufficient. BOK2 recommends that undergraduates be able to analyze a situation involving multiple conflicting professional and ethical interests to determine an appropriate course of action. This implies a higher level of attainment than just "understanding." While the task committee felt comfortable relying on the general criteria for professional responsibility, it felt that ethical responsibility demanded a higher standard for future professional civil engineers.

BOK2 outcomes not included: There were BOK2 outcomes that were not included in the proposed CEPC. These outcomes were considered valid but received lesser ratings of importance and feasibility than those outcomes that were included. Civil Engineering programs in the U.S. are tightly constrained and already have limited flexibility. Many state legislatures have mandated that CE programs be reduced to 128 semester hours in many jurisdictions and down to 120 semester hours in others. In large part, the exclusion or modification of the outcomes in the CEPC reflected the constraints facing CE programs today.

Specifically, the proposed CEPC are not "fully-BOK2-compliant" in the areas of public administration (Outcome #18), historical perspective (Outcome #11), globalization (Outcome #19), professional responsibility (Outcome #24), and leadership (Outcome #20). While the outcomes are covered in the proposed CEPC or the general ABET criteria, the standard is lower than specified in BOK2.

After much deliberation and debate, the consensus view of the CEPCTC was that these changes were of lesser importance and/or feasibility than the other new provisions related to project management, sustainability, professional ethics, and risk/uncertainty. The next iteration of the CEPCTC can reevaluate these provisions during the next cycle of proposed changes to the CEPC.

Some believe that there is an inherent conflict between the BOK2 and accreditation criteria. Some of the outcomes listed in BOK2 could be considered to be aspirational, unconstrained, and visionary. Accreditation criteria represent minimum standards and CE programs that fail to meet those minimum standards will cease to exist as accredited programs. It is therefore understandable that a gap might exist between the two. Furthermore, the body of knowledge needed by the civil engineer of the future is constantly evolving. While a few baccalaureate programs have revised their curriculum to include all of the BOK2 outcomes, mandating this change for all civil engineering programs over the next decade would be impractical.

Order of Presentation: The order of the phrases in the proposed program criteria was actually given considerable thought. The initial sentences more closely follow where and when these areas of study are within most civil engineering curriculums. The criteria begin with technical topics that progress from math and basic science through analysis and experimentation and finish with design. The middle portion covers the non-technical requirements and progresses from higher to lower levels on Bloom's taxonomy. The final portion covers ethics and professional responsibility. These were saved for the end to highlight their importance.

General Issues: There were several more general issues that merited discussion and decision by the CEPCTC.

- The existing CEPC and BOK2 Outcome #2 require that graduates solve problems in chemistry, physics and one additional area of science. The committee received feedback from some constituents that the extra area of science should be removed. The committee debated exhaustively on this topic. Both BOK1 and BOK2 place increased emphasis on math and science fundamentals. Both recommend a much broader science background so that future engineers are better equipped to adapt to emerging fields like biotechnology and nanotechnology. The requirement for "one additional area of natural science" reflects ASCE's intent that civil engineering graduates develop greater breadth in the basic sciences beyond the technical core subjects of physics and chemistry. However, the arguments for removing the additional area of science were also compelling. The leaders of some civil engineering programs believe that they are already overly constrained and any addition should be accompanied by the removal of something. Some programs are reluctantly replacing a second semester of chemistry or a third semester of physics for the additional area of science. Other programs are eliminating engineering science courses such as thermodynamics, rigid body dynamics or electrical circuits to make room for the additional area of science. Some believe that the additional science requirement removes flexibility from CE programs to pursue their own uniqueness. Ultimately, the committee believes that CE programs are constrained, but not overly constrained and there is still some room to accommodate the most important aspects of BOK1 and BOK2. Ultimately, the rationale that justified the additional area of science in the existing CEPC has not changed. The committee believes that removing the requirement would be a serious step backwards in a process that is clearly moving forwards.

  The discussion of this issue revealed a potential mismatch in standards between BOK2 Outcome #2 which is fairly prescriptive in the amount of natural science required at the undergraduate level while BOK Outcome #6 Mechanics simply requires undergraduates

to solve problems in solid and fluid mechanics. For a constrained CE program that is trying to make tough decisions on what to cut, the BOK2 seems to allow flexibility to cut electrical circuits and thermodynamics but offers no flexibility on the additional area of science. Whether this distinction was intentional or not can be addressed by the committee that creates the BOK3.

- There is a difference in documentation requirement for student outcomes in the ABET general criteria and requirements in the ABET program criteria. When documenting student outcomes in Criterion 4 of the general criteria, programs are required to demonstrate the degree to which students have attained the ABET 3 a-k student outcomes and any other outcomes the program has chosen to include. The program criteria are limited to areas involving curriculum and faculty qualifications. For the outcomes listed in the program criteria, the program must demonstrate sufficient coverage in the curriculum for the students to be able to attain the outcome, rather than demonstrating actual attainment of the outcome. For that reason, it might appear that the program criteria are less rigorous than the general criteria and may not be the best means of implementing the important elements of BOK2. The CEPCTC briefly considered other means such as an awards program to recognize those programs that choose to make their programs fully BOK2 compliant. Because it so much more cumbersome to change the general criteria[12], the committee concluded that the CEPC was the best available means for raising the bar and incorporating the key BOK2 outcomes into CE curricula.

- Feedback from some constituents noted that the CEPC seem to be more lengthy and prescriptive than most of the other engineering program criteria and questioned whether it was necessary. The various engineering professions have different needs, priorities and cultures. The civil engineering profession, for example, has championed the fulfillment of a body of knowledge for entry into the profession as a specific priority. The CEPC promote and reinforce that. Most professions have not developed a body of knowledge that specifies what an engineer should be able to do and at which level (baccalaureate, masters or equivalent, or experience) those skills should be attained. Because the civil engineering profession has developed an explicit body of knowledge, it is reasonable that the accreditation criteria should reflect and enforce those standards. Other engineering professions, while entirely reputable and respected, have not taken this initiative.

- The new Fundamentals of Engineering (FE) Examination contains questions in Hydraulics and Hydrologic Systems, Structural Analysis, Structural Design, Geotechnical Engineering, Transportation Engineering, Environmental Engineering, Construction and Surveying. Constituent feedback questioned if the CEPC should require coverage of all of these areas. The committee was aware of the structure of the new FE exam. While it would be nice to expand the breadth requirement to include all of the recognized sub-disciplines of civil engineering, this seemed unreasonable.

Future Work of the CEPCTC

As of this writing, the CEPCTC provided an initial email with the proposed criteria, justification, and frequently asked questions to priority one constituents and is in the process of collecting

feedback. The CEPCTC will continue to revise and execute its communication plan. Based on the feedback provided from constituents through email, the CEPCTC will consider revisions to the proposed CEPC prior to sending it forward for approval.

The tentative and partial schedule of the CEPCTC in completing its charge is as follows:

Event	Date (Approx)
Communication/coordination of draft proposed CEPC – primarily with ASCE stakeholders	December 2013 – April 2014
Formal presentation and discussion at National CE Department Heads' Meeting	April 2014
Session at 2014 ASEE Annual Conference (June 15-18, 2014; Indianapolis, IN)	June 2014
Draft CEPC reviewed by ABET/EAC (1st reading)	July 2014
Draft CEPC reviewed by ABET Board of Directors (1st reading)	October 2014
Public review of CEPC (conducted by the Engineering Accreditation Commission of ABET)	November 2014 – May 2015
CEPC reviewed by ABET/EAC (2nd/final reading)	July 2015
CEPC reviewed by ABET Board of Directors (2nd/final reading)	October 2015
First Reviews Under New CEPC	September 2016

Conclusions

The proposed CEPC is currently being communicated to all relevant constituents with the hope that the committee will receive constructive feedback. Appropriate changes will be made based on these discussions. Hopefully, the proposed CEPC will strike the best possible balance between raising the bar for the CE profession and recognizing the constraints imposed on CE programs. The CEPCTC has attempted to be thorough, deliberative, reasonable, and visionary in accomplishing its charge. This paper is an attempt to be open, communicative, and transparent as well.

Civil engineering is a dynamic profession. Change will always occur -- and the profession will need to make sure that future CEPC are relevant for future civil engineering students. However, it is also important that change is managed in a systematic, predictable, and responsible manner. ASCE has established an eight year cycle of updating the Civil Engineering Body of Knowledge and a corresponding eight year cycle of reviewing and updating the CEPC. The current CEPC was last updated effective for the 2008 – 2009 accreditation cycle, reflecting portions of BOK1. The CEPCTC is following the timeline proposed in these articles with the expectation that a revised version of the CEPC described in this paper will go into effect in September 2016 and BOK3 will be published by ASCE in March 2019. Subsequently, a new task committee will review the CEPC again in 2020 based on the BOK3, changes within the profession, and the existing constraints on the nation's CE programs -- with implementation of effective for the 2024-2025 accreditation cycle.

The CEPCTC concluded that there was room in existing CE curricula for three to four substantial accreditation changes. As these cycles of review continue, a saturation point could be

reached where there is no room to add a new accreditation requirement without removing an equivalent requirement from the existing criteria. Those compromises will be much tougher to reach.

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Appendix A

BOK2 Outcome Feasibility Ratings and Importance Rankings of the CEPCTC

Outcome Number & Title	BOK2 Outcome Statement	Bloom's Level of Outcome	CEPC Change (to make "Fully-BOK2-Compliant")	Average Feasibility Rating	Average Import-ance Ranking
Outcome #02 - 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.	3: Application	The program must prepare graduates to apply knowledge of mathematics through differential equations, calculus-based physics, chemistry, and at least one additional area of ~~basic~~ ***natural*** science, consistent with the program educational objectives; apply knowledge of four technical areas appropriate to civil engineering; conduct civil engineering experiments and analyze and interpret the resulting data; design a system, component, or process in more than one civil engineering context; explain basic concepts in management, business, public policy, and leadership; and explain the importance of professional licensure.	1.5	9
Outcome #03 - Humanities	Demonstrate the importance of the humanities in the professional practice of engineering.	3: Application	The program must demonstrate that graduates can: apply knowledge of mathematics through differential equations, calculus-based physics, chemistry, and at least one additional area of basic science, consistent with the program educational objectives; apply knowledge of four technical areas appropriate to civil engineering; ***demonstrate the importance of the humanities in the professional practice of engineering*** ; conduct civil engineering experiments and analyze and interpret the resulting data; design a system, component, or process in more than one civil engineering context; explain basic concepts in management, business, public policy, and leadership; and explain the importance of professional licensure.	2.5	16
Outcome #05 - Materials Science	Use knowledge of materials science to solve problems appropriate to civil engineering.	3: Application	The program must prepare graduates to apply knowledge of mathematics through differential equations, calculus-based physics, chemistry, and at least one additional area of basic science, consistent with the program educational objectives; apply knowledge of four technical areas appropriate to civil engineering; ***use knowledge of civil engineering materials to solve problems appropriate to civil engineering*** ; conduct civil engineering experiments and analyze and interpret the resulting data; design a system, component, or process in more than one civil engineering context; explain basic concepts in management, business, public policy, and leadership; and explain the importance of professional licensure.	1.7	7
Outcome #06 - Mechanics	Analyze and solve problems in solid and fluid mechanics.	4: Analysis	The program must prepare graduates to apply knowledge of mathematics through differential equations, calculus-based physics, chemistry, and at least one additional area of basic science, consistent with the program educational objectives; apply knowledge of four technical areas appropriate to civil engineering; ***analyze and solve problems in solid and fluid mechanics;*** conduct civil engineering experiments and analyze and interpret the resulting data; design a system, component, or process in more than one civil engineering context; explain basic concepts in management, business, public policy, and leadership; and explain the importance of professional licensure.	1.3	10
Outcome #07 – 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.	4: Analysis	The program must prepare graduates to apply knowledge of mathematics through differential equations, calculus-based physics, chemistry, and at least one additional area of basic science, consistent with the program educational objectives; apply knowledge of four technical areas appropriate to civil engineering; conduct civil engineering experiments and analyze and interpret the resulting data ***in more than one technical area of civil engineering;*** [~~analyze and interpret the resulting data~~ ***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***]; design a system, component, or process in more than one civil engineering context; explain basic concepts in management, business, public policy, and leadership; and explain the importance of professional licensure. **{Editor's note: within brackets "[" and "]" is a second alternative wording -- and blue colored font}**	2.2	18
Outcome #08 – Problem Recognition & Solving	Develop problem statements and solve well-defined fundamental civil engineering problems by applying appropriate techniques and tools.	3: Application	The program must prepare graduates to apply knowledge of mathematics through differential equations, calculus-based physics, chemistry, and at least one additional area of basic science, consistent with the program educational objectives; ***develop problem statements and solve problems in*** ~~apply knowledge of~~ four technical areas appropriate to civil engineering ***by applying appropriate techniques and tools*** ; conduct civil engineering experiments and analyze and interpret the resulting data; design a system, component, or process in more than one civil engineering context; explain basic concepts in management, business, public policy, and leadership; and explain the importance of professional licensure.	2.0	6

Outcome Number & Title	BOK2 Outcome Statement	Bloom's Level of Outcome	CEPC Change (to make "Fully-BOK2-Compliant")	Average Feasibility Rating	Average Import-ance Ranking
Outcome #10 - Sustainability	Apply the principles of sustainability to the design of traditional and emergent engineering systems.	3: Application	The program must demonstrate that graduates can: apply knowledge of mathematics through differential equations, calculus-based physics, chemistry, and at least one additional area of basic science, consistent with the program educational objectives; apply knowledge of four technical areas appropriate to civil engineering; ***apply knowledge of the principles of sustainability;*** conduct civil engineering experiments and analyze and interpret the resulting data; design a system, component, or process in more than one civil engineering context; explain basic concepts in management, business, public policy, and leadership; and explain the importance of professional licensure.	1.8	3
Outcome #11 – Contemporary Issues & Historic Perspectives	Drawing upon a broad education, explain the impact of historical and contemporary issues on the identification, formulation, and solution of engineering problems and explain the impact of engineering solutions on the economy, environment, political landscape, and society.	3: Application	The program must prepare graduates to apply knowledge of mathematics through differential equations, calculus-based physics, chemistry, and at least one additional area of basic science, consistent with the program educational objectives; apply knowledge of four technical areas appropriate to civil engineering; conduct civil engineering experiments and analyze and interpret the resulting data; design a system, component, or process in more than one civil engineering context; explain basic concepts in management, business, public policy, leadership; and explain the importance of professional licensure; ***explain the impact of historical and contemporary issues on the identification, formulation, and solution of engineering problems and explain the impact of engineering solutions on the economy, environment, political landscape, and society.***	2.5	8
Outcome #12 - Risk & Uncertainty	Apply the principles of probability and statistics to solve problems containing uncertainties.	3: Application	The program must prepare graduates to apply knowledge of mathematics through differential equations, calculus-based physics, chemistry, and at least one additional area of basic science, consistent with the program educational objectives; ***apply the principles of probability and statistics to solve problems containing uncertainties;*** apply knowledge of four technical areas appropriate to civil engineering; conduct civil engineering experiments and analyze and interpret the resulting data; design a system, component, or process in more than one civil engineering context; explain basic concepts in management, business, public policy, and leadership; and explain the importance of professional licensure.	1.8	1
Outcome #13 – Project Management	Develop solutions to well-defined project management problems.	3: Application	The program must prepare graduates to apply knowledge of mathematics through differential equations, calculus-based physics, chemistry, and at least one additional area of basic science, consistent with the program educational objectives; apply knowledge of four technical areas appropriate to civil engineering; conduct civil engineering experiments and analyze and interpret the resulting data; design a system, component, or process in more than one civil engineering context; ***apply basic concepts in project management*** ; explain basic concepts in ~~management~~, business, public policy, and leadership; and explain the importance of professional licensure.	1.7	5
Outcome #14 - Breadth in Civil Engineering	Analyze and solve well-defined engineering problems in at least four technical areas appropriate to civil engineering.	4: Analysis	The program must prepare graduates to apply knowledge of mathematics through differential equations, calculus-based physics, chemistry, and at least one additional area of basic science, consistent with the program educational objectives; ***analyze and solve well-defined engineering problems in at least*** ~~apply knowledge of~~ four technical areas appropriate to civil engineering; conduct civil engineering experiments and analyze and interpret the resulting data; design a system, component, or process in more than one civil engineering context; explain basic concepts in management, business, public policy, and leadership; and explain the importance of professional licensure.	1.3	4
Outcome #18 – Business and Public Administration	Explain key concepts and processes used in business and public administration.	2: Comprehension	The program must prepare graduates to apply knowledge of mathematics through differential equations, calculus-based physics, chemistry, and at least one additional area of basic science, consistent with the program educational objectives; apply knowledge of four technical areas appropriate to civil engineering; conduct civil engineering experiments and analyze and interpret the resulting data; design a system, component, or process in more than one civil engineering context; explain basic concepts in management, business, ***public administration*** , public policy, and leadership; and explain the importance of professional licensure.	2.2	15

Outcome Number & Title	BOK2 Outcome Statement	Bloom's Level of Outcome	CEPC Change (to make "Fully-BOK2-Compliant")	Average Feasibility Rating	Average Import-ance Ranking
Outcome #19 - Globalization	Organize, formulate, and solve an engineering problem in a global context.	3: Application	The program must prepare graduates to apply knowledge of mathematics through differential equations, calculus-based physics, chemistry, and at least one additional area of basic science, consistent with the program educational objectives; apply knowledge of four technical areas appropriate to civil engineering; conduct civil engineering experiments and analyze and interpret the resulting data; design a system, component, or process in more than one civil engineering context; ***organize, formulate, and solve an engineering problem within a global context;*** explain basic concepts in management, business, public policy, and leadership; and explain the importance of professional licensure.	2.5	14
Outcome #20 - Leadership	Apply leadership principles to direct the efforts of a small, homogenous group.	3: Application	The program must prepare graduates to apply knowledge of mathematics through differential equations, calculus-based physics, chemistry, and at least one additional area of basic science, consistent with the program educational objectives; apply knowledge of four technical areas appropriate to civil engineering; conduct civil engineering experiments and analyze and interpret the resulting data; design a system, component, or process in more than one civil engineering context; explain basic concepts in management, business, ***and*** public policy~~, and leadership~~; explain the importance of professional licensure; ***and apply leadership principles to direct the efforts of a small, homogenous group.***	2.2	13
Outcome #22 - Attitudes	Explain attitudes supportive of the professional practice of civil engineering.	2: Comprehension	The program must demonstrate that graduates can: apply knowledge of mathematics through differential equations, calculus-based physics, chemistry, and at least one additional area of basic science, consistent with the program educational objectives; apply knowledge of four technical areas appropriate to civil engineering; ***explain attitudes supportive of the professional practice of engineering;*** conduct civil engineering experiments and analyze and interpret the resulting data; design a system, component, or process in more than one civil engineering context; explain basic concepts in management, business, public policy, and leadership; and explain the importance of professional licensure.	2.0	11
Outcome #24 - Professional and Ethical Responsibility	Analyze a situation involving multiple conflicting professional and ethical interests to determine an appropriate course of action.	4: Analysis	The program must prepare graduates to apply knowledge of mathematics through differential equations, calculus-based physics, chemistry, and at least one additional area of basic science, consistent with the program educational objectives; apply knowledge of four technical areas appropriate to civil engineering; conduct civil engineering experiments and analyze and interpret the resulting data; design a system, component, or process in more than one civil engineering context; explain basic concepts in management, business, public policy, and leadership; ***analyze a situation involving multiple conflicting professional and ethical interests to determine appropriate course of action*** ; and explain the importance of professional licensure.	1.7	2

Appendix B:

SIDE-BY-SIDE COMPARISON
EXISTING CEPC vs PROPOSED CEPC
DRAFT AS OF DECEMBER 20, 2013

EXISTING CEPC	PROPOSED CEPC
1. Curriculum	1. Curriculum
The program must prepare graduates to apply knowledge of mathematics through differential equations, calculus-based physics, chemistry, and at least one additional area of basic science consistent with the program educational objectives;	The program must prepare graduates to apply knowledge of mathematics through differential equations, calculus-based physics, chemistry, and at least one additional area of ~~basic~~ natural science ~~consistent with the program educational objectives~~;
	apply principles of probability and statistics to solve problems containing uncertainty;
apply knowledge of four technical areas appropriate to civil engineering;	analyze and solve well-defined problems in at least ~~apply knowledge of~~ four technical areas appropriate to civil engineering;
conduct civil engineering experiments and analyze and interpret the resulting data;	conduct ~~civil engineering~~ experiments in more than one technical area of civil engineering and analyze and interpret the resulting data;
design a system, component, or process in more than one civil engineering context;	design a system, component, or process in more than one civil engineering context;
	apply principles of sustainability in design*;*
	apply principles of project management*;*
explain basic concepts in management, business, public policy, and leadership;	explain basic concepts in ~~management,~~ business, public policy, and leadership;
	analyze issues in professional ethics*;*
and explain the importance of professional licensure.	and explain the importance of professional licensure.
2. Faculty	2. Faculty
The program must demonstrate that faculty teaching courses that are primarily design in content are qualified to teach the subject matter by virtue of professional licensure, or by education and design experience. The program must demonstrate that it is not critically dependent on one individual.	No change

Underlined indicate additional wording relative to existing version. ~~Strikethrough~~ indicates deletion relative to existing version. Experiment phrase moved to right after probability and statistics.

Appendix C:
Proposed CEPC and Brief Justification

DRAFT CEPC	BRIEF JUSTIFICATION
1. Curriculum.	
The program must prepare graduates to apply knowledge of mathematics through differential equations, calculus-based physics, chemistry, and at least one additional area of ~~basic~~ natural science ~~consistent with the program educational objectives~~;	"Natural science" is a broader term than "basic science" allowing programs greater flexibility with the additional area of science. ABET requires the program to prepare graduates to attain the program educational objectives, and it is redundant to include the similar phrase in the program criteria.
apply principles of probability and statistics to solve problems containing uncertainty*;*	Beyond having a mathematical knowledge of (or course in) probability and statistics, civil engineers must deal with and manage risk and uncertainty.
conduct ~~civil engineering~~ experiments in more than one technical area of civil engineering and analyze and interpret the resulting data;	Adding an experimental breadth requirement to the criteria recognizes (1) the apparent reduction in high school and other experimental experiences of students entering engineering and (2) the trends in higher education to reduce laboratory experiences in curricula.
analyze and solve well-defined problems in at least ~~apply knowledge of~~ four technical areas appropriate to civil engineering;	"Analyze and solve" is considered to be a more accurate description of what programs are currently doing to meet the existing criteria; that is, to apply knowledge most programs already have students analyze and solve problems.
design a system, component, or process in more than one civil engineering context;	*No changes proposed.*
apply principles of sustainability in design*;*	ASCE is a recognized leader in this advancing area. While Criterion 3(c) of the general criteria lists "sustainability" as one of eight constraints that should be considered in a design, these eight constraints are preceded by the words "such as" and thus lacks the strength to ensure that *all* civil engineering graduates can apply the principles of sustainability.

apply principles of project management*;*	Rather than requiring "management," as in the current criteria, "project management" is considered more appropriate for civil engineering programs. The application of project management principles is applicable to all sub-disciplines of civil engineering. As such, this criterion does *not* imply that a specific sub-discipline (e.g., construction management) must be covered.
explain basic concepts in ~~management,~~ business, public policy, and leadership;	*No changes other than removing "management."*
analyze issues in professional ethics*;*	General Criterion 3(f) requires an understanding of ethical responsibility, which falls short of addressing ethical decision-making and, more importantly, ethical and professional behavior. This implies a higher level of attainment than just "understanding." While the general criteria adequate addresses professional responsibility, ethical responsibility demands a higher standard for civil engineering graduates.
and explain the importance of professional licensure.	*No changes proposed.*
2. Faculty.	
The program must demonstrate that faculty teaching courses that are primarily design in content are qualified to teach the subject matter by virtue of professional licensure, or by education and design experience. The program must demonstrate that it is not critically dependent on one individual.	*No changes proposed.*