cultivating allies, and ultimately achieving a critical mass of support on the ABET Board of Directors. Persistence will continue to serve ASCE well in overcoming opposition to other aspects of the Raise the Bar initiative.

- Changes to accreditation criteria require intensive communication and coordination with all relevant constituencies—but most importantly with civil engineering department heads. And this communication must continue long after the new criteria are implemented, because of the high rate of turnover among department heads and other educational leaders.

## Recommendations for the Future

Over the past decade, ASCE's Raise the Bar initiative has achieved many successes, but has also experienced a number of failures, false starts, and less-than-optimal paths to desired goals. Nonetheless, successes and failures alike have contributed to advancing the initiative—enhancing our understanding of a very complex professional environment, while informing our subsequent efforts to move forward. As new Raise the Bar leaders take charge, they should take advantage of these lessons to the greatest extent possible.

Based on the historical analysis presented in this paper, the author provides the following recommendations for the future of the Raise the Bar initiative:

- Implement future updates of the Civil Engineering BOK and associated accreditation criteria according to a long-term schedule based on a predictable eight-year cycle.

- For all future accreditation criteria updates, use the approach depicted in Figure 1 for translating BOK outcomes into criteria provisions.

- Continue to use Bloom's Taxonomy as the basis for defining desired levels of achievement in both BOK outcomes and accreditation criteria.

- In conjunction with the development of new accreditation criteria, create two separate supplemental guidance documents—one providing a scholarly rationale for each provision of the new criteria and one providing specific operational guidelines for criteria compliance.

- Develop a plan for the implementation of **B + M$^{ABET}$ & E** as an alternate path to BOK fulfillment and licensure.

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Appendix A. BOK1-Compliant Civil Engineering Program Criteria and General Criteria for Master's Level Programs, as submitted to the EAC of ABET

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 demonstrate that graduates can: apply knowledge of mathematics through differential equations, calculus-based physics, chemistry, and at least one additional area of 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.

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.

II. GENERAL CRITERIA FOR MASTERS LEVEL PROGRAMS

Masters level programs must develop, publish, and periodically review, educational objectives and program outcomes. The criteria for masters level programs are fulfillment of the baccalaureate level general criteria, fulfillment of program criteria appropriate to the masters level specialization area, and one academic year of study beyond the baccalaureate level. The program must demonstrate that graduates have an ability to apply masters level knowledge in a specialized area of engineering related to the program area.

Appendix B

# Comparison of BOK1 Requirements and ABET Criteria

| Civil Engineering Body of Knowledge | | ABET Engineering Criteria | | |
|---|---|---|---|---|
| **Outcome Statement** | **Specific Provisions or Requirements** | **General Criteria for Baccalaureate Level Programs** | **General Criteria for Master's Level Programs** | **CE Program Criteria** |
| 1. An ability to apply knowledge of mathematics, science, and engineering | Breadth of coverage in mathematics, science and civil engineering topics | 3(a) An ability to apply knowledge of mathematics, science, and engineering | | 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. |
| | Mathematics through differential equations, probability and statistics, calculus-based physics, biology, chemistry, ecology, geology, geomorphology, engineering economics, mechanics, material properties, systems, geo-spatial representation, and information technology | | | |
| | Understand fundamentals of several recognized major civil engineering areas | | | |
| 2. An ability to design and conduct experiments, as well as to analyze and interpret data | Design and conduct field and laboratory studies, gather data, create numerical and other models, and then analyze and interpret the results—in at least one of the evolving or current major civil engineering areas | 3(b) An ability to design and conduct experiments, as well as to analyze and interpret data | | Conduct civil engineering experiments and analyze and interpret the resulting data |
| 3. An ability to design a system, component, or process to meet desired needs | Problem definition, scope, analysis, risk assessment, environmental impact statements, creativity, synthesizing alternatives, iteration, regulations, codes, safety, security, constructability, sustainability, and multiple objectives and various perspectives | 3(c) An ability to design a system, component, or process to meet desired needs | | Design a system, component, or process in more than one civil engineering context |
| | Bidding versus qualifications-based selection; estimating engineering costs; interaction between planning, design and construction; design review; owner-engineer relationships; and life-cycle assessment | | | |
| | Understanding large-scale systems, including the need to integrate information, organizations, people, processes, and technology | | | |
| | Design experiences integrated throughout the professional component of the curriculum | | | |
| 4. An ability to function on multi-disciplinary teams | Lead a design team or other team | 3(d) An ability to function on multi-disciplinary teams | | |
| | Participate as a member of a team | | | |
| | Team formation and evolution, personality profiles, team dynamics, collaboration among diverse disciplines, problem solving, time management, and being able to foster and integrate diversity of perspectives, knowledge, and experiences | | | |

| Civil Engineering Body of Knowledge | | ABET Engineering Criteria | | |
|---|---|---|---|---|
| **Outcome Statement** | **Specific Provisions or Requirements** | **General Criteria for Baccalaureate Level Programs** | **General Criteria for Master's Level Programs** | **CE Program Criteria** |
| 5. An ability to identify, formulate and solve engineering problems | Assessing situations in order to identify engineering problems, formulate alternatives, and recommend feasible solutions | 3(e) An ability to identify, formulate and solve engineering problems | | |
| 6. An understanding of professional and ethical responsibility | Hold paramount public safety, health, and welfare | 3(f) An understanding of professional and ethical responsibility | | Explain the importance of professional licensure |
| | Thoughtful and careful weighing of alternatives when values conflict | | | |
| | understanding of and commitment to practice according to the seven Fundamental Canons of Ethics and the associated Guidelines to Practice Under the Fundamental Canons of Ethics | | | |
| 7. An ability to communicate effectively | Listening, observing, reading, speaking, and writing | 3(g) An ability to communicate effectively | | |
| | Fundamentals of interacting effectively with technical and non-technical or lay individuals and audiences in a variety of settings | | | |
| | Versatility with mathematics, graphics, the worldwide web and other communication tools | | | |
| 8. The broad education necessary to understand the impact of engineering solutions in a global and societal context | Appreciate, from historical and contemporary perspectives, culture, human and organizational behavior, aesthetics and ecology and their impacts on society | 3(h) the broad education necessary to understand the impact of engineering solutions in a global, and societal context | | |
| | History and heritage of the civil engineering profession | | | |
| 9. A recognition of the need for, and an ability to engage in, life-long learning | Life-long learning mechanisms—additional formal education, continuing education, professional practice experience, active involvement in professional societies, community service, coaching, mentoring, and other learning and growth activities | 3(i) A recognition of the need for, and an ability to engage in, life-long learning | | |
| | Personal and professional development—developing understanding of and competence in goal setting, personal time management, communication, delegation, personality types, networking, leadership, the socio-political process, effecting change, career management, increasing discipline knowledge, understanding business fundamentals, contributing to the profession, self-employment, additional graduate studies, and achieving licensure and specialty certification | | | |

| Civil Engineering Body of Knowledge | | ABET Engineering Criteria | | |
|---|---|---|---|---|
| **Outcome Statement** | **Specific Provisions or Requirements** | **General Criteria for Baccalaureate Level Programs** | **General Criteria for Master's Level Programs** | **CE Program Criteria** |
| 10. A knowledge of contemporary issues | relationship of engineering to critical contemporary issues such as multicultural globalization of engineering practice; raising the quality of life around the globe; the growing diversity of society; and the technical, environmental, societal, political, legal, aesthetic, economic, and financial implications of engineering projects | 3(j) A knowledge of contemporary issues | | |
| 11. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice | Role and use of appropriate information technology, contemporary analysis and design methods, and applicable design codes and standards as practical problem-solving tools to complement knowledge of fundamental concepts<br>Ability to select the appropriate tools for solving different types and levels of problems | 3(k) An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice | | |
| 12. An ability to apply knowledge in a specialized area related to civil engineering | Specialized technical coursework (or equivalent) in such areas as environmental engineering, structural engineering, construction engineering and management, public works management, transportation engineering and water resources management | | One academic year of study beyond the basic level<br>Ability to apply advanced level knowledge in a specialized area of engineering | |
| 13. An understanding of the elements of project management, construction, and asset management | Project management—project manager responsibilities, defining and meeting client requirements, risk assessment and management, stakeholder identification and involvement, contract negotiation, project work plans, scope and deliverables, budget and schedule preparation and monitoring, interaction among engineering and other disciplines, quality assurance and quality control, and dispute resolution processes.<br>Construction—owner-engineer-contractor relationships; project delivery systems (e.g., design-bid-build, design-build); estimating construction costs; bidding by contractors; labor and labor management issues; and construction processes, methods, systems, equipment, planning, scheduling, safety, cost analysis and cost control.<br>Asset management—effective and efficient long-term ownership of capital facilities via systematic acquisition, operation, maintenance, preservation, replacement, and disposition. | | | Explain basic concepts in management |

| Civil Engineering Body of Knowledge | | ABET Engineering Criteria | | |
|---|---|---|---|---|
| **Outcome Statement** | **Specific Provisions or Requirements** | **General Criteria for Baccalaureate Level Programs** | **General Criteria for Master's Level Programs** | **CE Program Criteria** |
| 14. An understanding of business and public policy and administration fundamentals | Business—legal forms of ownership, organizational structure and design, income statements, balance sheets, decision (engineering) economics, finance, marketing and sales, billable time, overhead, and profit | | | Explain basic concepts in business and public policy |
| | Public policy and administration—political process, public policy, laws and regulations, funding mechanisms, public education and involvement, government-business interaction, and public service responsibility of professionals | | | |
| 15. An understanding of the role of the leader and leadership principles and attitudes. | Leading—broad motivation, direction, and communication knowledge and skills | | | Explain basic concepts in leadership |
| | Attitudes—commitment, confidence, curiosity, entrepreneurship, high expectations, honesty, integrity, judgment, persistence, positiveness, and sensitivity | | | |
| | Behaviors—earning trust, trusting others, formulating and articulating vision, communication, rational thinking, openness, consistency, commitment to organizational values, and discretion with sensitive information | | | |

## Appendix C. BOK2 Outcomes and Levels of Achievement[13]

| Outcome number and title | Level of achievement | | | | | |
|---|---|---|---|---|---|---|
| | 1 Know-ledge | 2 Compre-hension | 3 Appli-cation | 4 Analy-sis | 5 Synthe-sis | 6 Evalu-ation |
| **Foundational** | | | | | | |
| 1. Mathematics | B | B | B | | | |
| 2. Natural sciences | B | B | B | | | |
| 3. Humanities | B | B | B | | | |
| 4. Social sciences | B | B | B | | | |
| **Technical** | | | | | | |
| 5. Materials science | B | B | B | | | |
| 6. Mechanics | B | B | B | B | | |
| 7. Experiments | B | B | B | B | M/30 | |
| 8. Problem recognition and solving | B | B | B | M/30 | | |
| 9. Design | B | B | B | B | B | E |
| 10. Sustainability | B | B | B | E | | |
| 11. Contemp. Issues & hist. perspectives | B | B | B | E | | |
| 12. Risk and uncertainty | B | B | B | E | | |
| 13. Project management | B | B | B | E | | |
| 14. Breadth in civil engineering areas | B | B | B | B | | |
| 15. Technical specialization | B | M/30 | M/30 | M/30 | M/30 | E |
| **Professional** | | | | | | |
| 16. Communication | B | B | B | B | E | |
| 17. Public policy | B | B | E | | | |
| 18. Business and public administration | B | B | E | | | |
| 19. Globalization | B | B | B | E | | |
| 20. Leadership | B | B | B | E | | |
| 21. Teamwork | B | B | B | E | | |
| 22. Attitudes | B | B | E | | | |
| 23. Life-long learning | B | B | B | E | E | |
| 24. Professional and ethical responsibility | B | B | B | B | E | E |

Key:

| | |
|---|---|
| B | Portion of the BOK fulfilled through the bachelor's degree |
| M/30 | Portion of the BOK fulfilled through the master's degree or equivalent (approximately 30 semester credits of acceptable graduate-level or upper- level undergraduate courses) |
| E | Portion of the BOK fulfilled through the pre-licensure experience |

## Chapter 6

# Response of Three Curricula to ASCE's Educational Recommendations

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