Raise the Bar

Strengthening the Civil Engineering Profession

Edited by
Jeffrey S. Russell, Ph.D., P.E.
Thomas A. Lenox, Ph.D.

ASCE

Raise the Bar

Strengthening the Civil Engineering Profession

Edited by

Jeffrey S. Russell, Ph.D., P.E.

Thomas A. Lenox, Ph.D.

ASCE

Library of Congress Cataloging-in-Publication Data

Raise the bar : strengthening the civil engineering profession / edited by Jeffrey S. Russell, Ph.D., P.E. Thomas A. Lenox, Ph.D.
pages cm
Includes bibliographical references and index.
ISBN 978-0-7844-1317-3 (print : alk. paper) -- ISBN 978-0-7844-7801-1 (ebook) 1. Engineering--Vocational guidance. 2. Civil engineering--Study and teaching. 3. Civil engineers--Certification. 4. Civil engineering--Standards. I. Russell, Jeffrey S., editor of compilation. II. Lenox, Thomas A., editor of compilation.
TA157.R27 2013
331.7'624--dc23
2013031402

Published by American Society of Civil Engineers
1801 Alexander Bell Drive
Reston, Virginia, 20191-4400
www.asce.org/pubs

ISBN 978-0-7844-1317-3 (paper)
ISBN 978-0-7844-7801-1 (PDF)
Manufactured in the United States of America.

Contents

This page intentionally left blank

Preface

Background

Key educational and professional leaders of the civil engineering community in the United States met at the American Society of Civil Engineers (ASCE) Civil Engineering Education Conference (CEEC '95) in June 1995 in Denver, Colorado. They were concerned that rapid technological advancement, globalization, and ever-increasing political, social, environmental, and economic constraints were fundamentally changing the practice of civil engineering. These leaders believed that many academic institutions were ill-equipped to respond to these challenges, because of the significant downward trend in credit hours required for an accredited four-year engineering baccalaureate degree. As a result, they were convinced that the baccalaureate degree was becoming increasingly inadequate as the formal academic preparation for the professional practice of civil engineering.

In response to the call for action from CEEC '95, the American Society of Civil Engineers (ASCE) Board of Direction adopted Policy Statement 465 in October 1998. The initial version of the policy stated that the Society "supports the concept of the master's degree as the First Professional Degree for the practice of civil engineering at the professional level." As the strategy for achieving this vision developed, it became apparent that the policy should more broadly address the academic prerequisites for professional practice and licensure, rather than focusing only on the attainment of a specific academic degree. Hence, in October 2001, the ASCE Board adopted a modified version of Policy 465, indicating that ASCE "supports the concept of the master's degree or equivalent as a prerequisite for licensure and the practice of civil engineering at the professional level." Soon thereafter, the ASCE Board charged a new Committee on Academic Prerequisites for Professional Practice (CAP^3) with implementing Policy 465. While ASCE Policy 465 would be refined and revised three more times over the next decade, the charge to CAP^3 would be unchanging:

> *Develop, organize, and execute a detailed plan for the full realization of ASCE Policy Statement 465 (Academic Prerequisites for Licensure and Professional Practice). The Committee's activities shall be organized to occur in a concurrent, integrated, and coordinated manner across the broad areas of civil engineering body of knowledge, curriculum development, accreditation, and licensing.*

From the work of CAP^3 arose one of the most significant civil engineering educational and professional reform initiatives of the last several decades – the Raise the Bar Initiative.

Purpose and Scope

The editors believe that the successful processes of the past and the associated "lessons learned" must be clearly communicated to future leaders and proponents of the "Raise the Bar" initiative. Much has been learned from the experiences of the past – and these hard-learned experiences should guide the future direction of this ongoing initiative. A relevant quotation (from Adlai E. Stevenson, a former Governor of Illinois and two-time presidential candidate) comes to mind: “We can chart our future clearly and wisely only when we know the path which has led to the present.”

While hundreds of papers and articles have been published related to the Raise the Bar Initiative over the last fifteen years, the editors have carefully selected ten papers that (1) include current and accurate information about one of the broad areas of civil engineering body of knowledge, curriculum development, experiential development, accreditation, or licensing; (2) are foundational to changing the future of civil engineering and/or (3) are of enduring value. Collectively the papers provide the reader with an integrated and holistic perspective of the Raise the Bar Initiative.

As a group, the ten papers of this volume provide engineering educators and practitioners with a description of the history, lessons learned, and the next steps related to the Raise the Bar Initiative. The first of the ten papers provides a summary of the overall initiative from 1995 through 2012 as witnessed and experienced by the two editors of this volume -- the long-term leaders of CAP^3. The second paper assesses the Raise the Bar Initiative from the perspective of the sociological theory of professions. The third paper describes a vision of civil engineering for 2025 resulting from the Summit on the Future of Civil Engineering of June 2006 – a meeting that laid the foundation for a refined civil engineering body of knowledge. The next five papers were written about five different, yet closely related, aspects of the Raise the Bar Initiative including the (1) civil engineering bodies of knowledge, (2) revised accreditation criteria, (3) changed university curricula, (4) experiential guidelines, and (5) modified licensure laws and rules. The ninth paper assesses the key points made by the opponents to the Raise the Bar initiative as presented in the position paper of the American Society of Mechanical Engineers titled “Mandatory Educational Requirements for Engineering Licensure.” The final paper summarizes “leadership lessons learned” from a decade-long major change process including ideas about how to lead any change effort. Each of these ten papers includes an extensive bibliography related to its focus area. In addition, Appendix B of the first paper is a special annotated list of over 100 papers related to the Raise the Bar initiative that have been published by the American Society for Engineering Education (ASEE) since 1998. All of these ASEE papers can be downloaded from http://www.asee.org/search/proceedings.

Acknowledgments

The editors’ experiences with the Raise the Bar initiative supports the view of Phil Jackson, Hall of Fame basketball player and coach, that “The strength of the team is each individual member -- the strength of each member is the team.” Each of authors of the ten papers included in this volume is a nationally renowned leader of the engineering profession. A short biographical summary of each author’s career is included in the About the Contributors section in this volume. Equally important as their individual credentials, the authors of these ten papers have been long-time members of ASCE’s Raise the Bar Team – working together to make sure that future civil engineers are properly prepared for their futures as part of a learned profession.

Many other individuals were also key leaders and members of the Raise the Bar Team. In large part, these include the dedicated engineering professionals who worked on various ASCE CAP^3 committees. These individuals are listed in Appendix C of the first paper of this volume. An examination of this list shows that the work to Raise the Bar for the engineering profession was not accomplished by a small group of reform-minded individuals, but a robust group of dedicated, committed, and concerned change agents.

The editors also wish to express their gratitude to the presidential officers of the American Society of Civil Engineers for their unfailing support of the Raise the Bar Initiative since 1998. The continuity of their support, vision, and leadership was critical to the furthering of the Raise the Bar initiative. Their names are listed in Appendix D of the first paper of this volume.

The long-time leaders of CAP^3 have "passed the torch" of the Raise the Bar Initiative to the leaders of a new national committee -- appropriately named the Raise the Bar Committee. The chair of the Raise the Bar Committee is ASCE President-Emeritus Blaine Leonard, and the committee's primary staff supporters are Stefan Jaeger and Mark Killgore. The current focus of the committee is to influence state licensing boards to Raise the Bar for future professional engineers. The editors of this volume are fully confident that the critical reform efforts as reported in this volume will continue under their leadership.

The editors express their sincere appreciation to the staff members of ASEE who have granted the appropriate permissions to print several of ASEE's *Proceedings* papers. This includes Norman Fortenberry, Mark Matthews, and Wayne Davis. They also wish to express their heartfelt gratitude to the three members of ASCE's publication staff who have worked so conscientiously and expertly to make this publication possible. This includes Bruce Gossett, Betsy Kulamer, and Donna Dickert.

Dedication

The editors dedicate this work to Richard O. Anderson, P.E., Dist.M.ASCE; Gerald E. Galloway, Ph.D., P.E., NAE, Hon.D.WRE, Dist.M.ASCE; and Stuart G. Walesh, Ph.D., P.E., D.WRE, Dist.M.ASCE. These three individuals have been the ultimate selfless servants of the engineering profession by leading and/or serving on CAP^3-related committees continuously from 1998 through 2012. Collectively, they have been the heart and spirit of the Raise the Bar Initiative.

This page intentionally left blank

Chapter 1

A Historical Overview

Jeffrey S. Russell, Ph.D., P.E., Dist.M.ASCE, NAC, F.NSPE, ***University of Wisconsin-Madison***

Thomas A. Lenox, Ph.D., Dist.M.ASCE, ***American Society of Civil Engineers***

Originally published as "The Raise the Bar Intiative: Charting the Future by Understanding the Path to the Present—A Historical Overview," in *Proceedings of the 2012 Conference of the American Society for Engineering Education,* June 2012.

The Raise the Bar Initiative: Charting the Future by Understanding the Path to the Present – A Historical Overview

Background

Beginning in 1995 at the American Society of Civil Engineers (ASCE) Civil Engineering Education Conference (CEEC ’95), key educational and professional leaders of the civil engineering community in the United States began working to reform civil engineering education.[3] In 1998, the call for action from CEEC ’95 ultimately resulted in the passage of ASCE Policy Statement 465—Academic Prerequisites for Licensure and Professional Practice. Policy 465 states that, in the future, education beyond the baccalaureate degree will be necessary for entry into the professional practice of civil engineering.[6] In 2003, an ASCE Board-level committee, the Committee on Academic Prerequisites for Professional Practice (CAP^3), was formed to study and implement the actions that would be necessary to achieve this vision for civil engineering. The last fourteen years since Policy 465 was first approved have produced significant progress in ASCE’S “Raise the Bar” initiative.

Purpose and Scope

To maintain the initiative’s momentum, the successful processes of the past and the associated “lessons learned” must be clearly communicated to future leaders and proponents of the “Raise the Bar” initiative. Much has been learned from the experiences of the past – and these hard-learned experiences should guide the future direction of the initiative. A relevant quotation (from Adlai E. Stevenson) comes to mind: “We can chart our future clearly and wisely only when we know the path which has led to the present.”

This is one of six scholarly papers that are scheduled for presentation at the 2012 American Society for Engineering Education (ASEE) Annual Conference in San Antonio in recognition of approaching the tenth year of CAP^3. As a group, the six papers provide engineering educators and practitioners with a description of the history, lessons learned, and the next steps related to the “Raise the Bar" initiative.

This paper, the first of the six papers, provides a summary of the overall initiative as witnessed and experienced by two of the long-term leaders of CAP^3. The other five papers were written from five different, yet closely related, perspectives including the (1) civil engineering bodies of knowledge, (2) revised accreditation criteria, (3) changed university curricula, (4) experiential guidelines, and (5) modified licensure laws and rules. Much of the summary in this first paper is presented in tabular form, not duplicating the more detailed information written in the other five papers. All six papers are published in the *Proceedings of the 2012 Annual Conference of the American Society for Engineering Education* of June 2012. As such, this paper is not meant to be a “stand alone document” – it was written to connect and bond the content included in its five “companion” papers:

1. Walesh, S. (2012). "The BOK and Leadership Lessons Learned."[42]
2. Ressler, S. (2012). "The Raise the Bar Initiative: Charting the Future by Understanding the Path to the Present -- Accreditation Criteria."[30]
3. Nelson, J.K.; Fridley, K.; and Hall, K. (2012). "The Raise the Bar Initiative: Charting the Future by Understanding the Path to the Present -- How Are BSCE Curricula Responding?"[25]
4. Phillips, M. and Holly, F. (2012). "The Raise the Bar Initiative: Charting the Future Through Strengthened Experiential Guidelines."[28]
5. Nelson, Jon; Musselman, C.; Conzett, M.; and Phillips, M., and Anderson, K. (2012). "The Raise the Bar Initiative: Charting the Future by Understanding the Path to the Present -- Modifying the Model Laws and Rules for Engineering Licensure." [26]

Summary and Tabular History of the Raise the Bar Initiative

A history of the Raise the Bar initiative in tabular form is shown in Appendix A. The authors have included most of the significant events directly related to the initiative between 1995 and mid-2012 in this chronological list. Several other events that indirectly, but significantly, influenced the initiative are also listed. The record (row of table) for each event includes:

- Reference number.
- Name of the professional organization(s) leading this event/project.
- Event/project name.
- Short explanatory remarks about the event/project.
- Names of primary leaders of the event/project.

The history of the Raise the Bar initiative within ASCE pre-dates the 2003 start date of ASCE's Committee on the Academic Prerequisites for Professional Practice (CAP^3). As such, the authors chose to begin the tabulated history with the ASCE Civil Engineering Education Conference of June 1995 (CEEC '95). This event marked the beginning of ASCE's focused involvement in the Raise the Bar initiative. Both of the authors attended this historic event.

A Short Summary of the History of the Raise the Bar Initiative

A condensed summary of the events tabulated in Appendix A could be logically organized into six periods of time. The first five of the six time periods are approximately three years in duration. Each of these first five periods ends with the passing of a new and/or refined version of ASCE Policy Statement 465 (Academic Prerequisites for Licensure and Professional Practice) by the then-current ASCE Board of Direction (BOD). The sixth and shortest period bring us to the present. The authors' condensed summary is as follows:

1995-1998: Working Towards an Initial Policy
(see Events #1 to #4, Appendix A)

While the history of Raise the Bar initiative could be traced back as far as the Mann report of 1918,[21] ASCE's focused attention to this issue began with the preparation for, conduct of, and report of the 1995 Civil Engineering Education Conference (CEEC '95) in Denver. One of the key findings of CEEC '95 was that "an additional period of study, recognized by a professional degree, is required before entering practice."[3] Subsequently, ASCE leaders organized the Task Committee on Civil Engineering Education Initiatives (TCCEEI) to recommend the next steps in implementing the findings of CEEC '95. Ultimately, the work of the TCCEEI resulted in passing the initial ASCE Policy 465 by the ASCE Board of Direction. The initial ASCE Policy 465 stated in part:

> *ASCE supports the concept of the Master's degree as First Professional Degree for the practice of civil engineering at a professional level.*

1998 to 2001: Communicating the Policy's Intent – the Master's or Equivalent (MOE).
(see Events #5 to #8, Appendix A)

Many ASCE members appeared to be surprised by the new ASCE Policy 465 of 1998 when announced in the *ASCE News* in November 1998. The rationale and the plan for implementing the new policy may not have been clearly articulated by the leadership of ASCE to its members. Subsequently the Task Committee for the First Professional Degree (TCFPD) was charged to develop a vision of the full realization of the new ASCE Policy 465 – and a strategy for achieving this vision. The work of the TCFPD resulted in explicit guidance to ASCE to move forward with the Raise the Bar initiative to include a recommendation for a refined ASCE Policy 465:[4]

> *ASCE supports the concept of master's degree or equivalent as a prerequisite for licensure and the practice of civil engineering at a professional level.*

While ASCE's TCFPD was working between October 1999 and October 2001 to fulfill its charge, the National Council of Examiners for Engineering & Surveying (NCEES) was beginning to critically review the educational and experiential preparation of future profession engineers.[26] This exhaustive review and analysis began with the establishment of NCEES's Engineering Licensure Qualifications Task Force (ELQTF) in October 2000. NCEES invited over 20 engineering societies to participate on the task force. ASCE and nine other professional societies (AAEE, ABET, ACEC, ASHRAE, ASME, CEQB, EDC/ASEE, IEEE-USA, and NSPE) participated in this NCEES-sponsored task force. Each of the ten society members had full voting rights during the deliberations.

2001 to 2004: Developing and Publishing a First-Ever Civil Engineering Body of Knowledge.
(see Events #9 to #18, Appendix A)

In October 2001, TCFPD "passed the torch" within ASCE to the Task Committee on the Academic Prerequisites for Professional Practice (TCAP^3). This task committee was charged to ". . . develop, organize, and execute a detailed plan for the full realization of ASCE Policy 465." As a manifestation of the ASCE BOD's long-term commitment to the Raise the Bar initiative, TCAP^3 was changed to a standing BOD-level committee – the Committee on the Academic Prerequisites for Professional Practice (CAP^3) -- in 2003.

During this period, much of the key foundational work of the Raise the Bar initiative began within ASCE, NCEES, NAE, and NSPE – and a great deal completed. In January 2002, the NSPE Board approved a policy statement supporting "the concept of engineering students meeting additional academic requirements as a prerequisite for licensure and practice of engineering at the professional level . . . . additional requirements could include a master's degree or equivalent." In August 2003, the ELQTF presented its final report to the NCEES Council recommending that ". . . additional coursework be added to the current bachelor's programs and that the bodies of knowledge required for each program be stipulated."[26] In April 2004, the National Academy of Engineering (NAE) published its trailblazing work, *The Engineer of 2020 – Visions of Engineering in the New Century* stating that ". . . we should reconstitute engineering curricula and related educational programs to prepare today's engineers for the careers of the future."[22] And, in February 2004, after almost two years of intense work, the CAP^3 Body of Knowledge Committee published the first-ever *Civil Engineering Body of Knowledge (BOK1)*.[7] In October 2004, the ASCE BOD confirmed its support of the critical linkage between the Raise the Bar initiative and the CE BOK by refining ASCE Policy 465:

> *ASCE supports attainment of a body of knowledge for entry into the practice of civil engineering at the professional level. This would be accomplished through the adoption of appropriate engineering education and experience requirements as a prerequisite for licensure.*[6]

<u>2004 to 2007: Visioning the Future of Civil Engineering and Refining the Body of Knowledge.</u>
(see Events #19 to #25, Appendix A)

During this period, much of the scholarly foundational work of the Raise the Bar initiative was continued within NAE and ASCE – and the changes to the engineering licensure laws/rules to implement Raise the Bar began in earnest within NCEES. In September 2005, NAE published *Educating the Engineer of 2020 – Adapting Engineering Education to the New Century* stating that "It is evident that the exploding body of science and engineering knowledge cannot be accommodated within the context of the traditional four-year baccalaureate degree."[23] Within ASCE, a Vision 2025 Summit was planned, organized, and conducted in June 2006 to articulate an aspirational global vision for the future of civil engineering. In parallel, ASCE organized a Second Edition of the Body of Knowledge Committee in October 2005 to refine the first edition of the BOK to include (1) incorporating the concepts of NAE's *Educating the Engineer of 2020* and (2) monitoring the concurrent work of the ASCE Vision 2025 Summit.

During this period, significant work was done by NCEES to incorporate the principles of Raise the Bar in the licensure process. To further explore the ELQTF findings, NCEES formed a Licensure Qualifications Oversight Group (LQOG) in September 2003. LQOG presented its final report to the NCEES Council in August 2005. Based upon LQOG's report, and the implementation work of NCEES's Uniform Procedures and Legislative Guidelines Committee

(UPLG) in 2005-2006, the NCEES Council voted to modify the Model Law requirements for licensure to require additional education for engineering licensure no sooner than 2015. The approved language stated that an engineer intern with a bachelor's degree must have an additional 30 credits of acceptable upper-level undergraduate or graduate-level coursework from approved providers in order to be admitted to the Principles and Practice of Engineering (PE) examination. This is considered by many proponents of Raise the Bar as the key event to move the initiative forward.[26]

The end of this period is marked by the reconfirmation, in October 2007, of the ASCE BOD of its continued support of the Raise the Bar initiative and the BOK by further refining ASCE Policy 465:

> *ASCE supports the attainment of a Body of Knowledge . . . The Body of Knowledge includes (1) the fundamentals of math, science, and engineering science, (2) technical breadth, (3) breadth in the humanities and social sciences, (4) professional practice breadth, and (5) technical depth or specialization. Fulfillment of the Body of Knowledge requires additional education beyond the bachelor's degree for the practice of civil engineering at the professional level.*

2007 to 2010: Motivating Curricula Reform Using New Accreditation Criteria and the Second Edition of the Body of Knowledge.

(see Events #26 to #40, Appendix A)

Following the submission of proposed new BOK1-compliant accreditation criteria to the Engineering Accreditation Commission of ABET in June 2006, these criteria achieved final approval by the ABET Board of Directors in October 2007. These new criteria included both civil engineering program criteria and master's level general criteria. They were implemented for accreditation visits starting in the fall of 2008. Given the six-year ABET accreditation cycle, all U.S. civil engineering programs will have been evaluated under these BOK1-compliant criteria by Academic Year 2013-14.[31]

Another historic accreditation-related event occurred during this period. After an intensive ASCE lobbying effort, the ABET Board of Directors voted to remove the prohibition on dual level accreditation of engineering programs in March 2008. As a result of this policy change and the implementation of new master's-level general accreditation criteria, effective in the fall of 2008, the alternate path (B + M-ABET & E) has become a viable route to BOK attainment.

While new BOK1-compliant accreditation criteria were being finalized and implemented, it became apparent that significant updates to BOK1 itself would be required. These revisions were driven by (1) aspects of the 1st Edition that did not lend themselves to effective measurement and assessment; and (2) publication of several strategic vision documents that called for future engineers to develop certain knowledge, skills, and attitudes that had *not* been included in BOK1. As a result, a second edition of the Civil Engineering BOK was initiated in October 2005 and published in February 2008. The *Civil Engineering Body of Knowledge for the*

21st Century, *Second Edition,*[10] (abbreviated BOK2) incorporates two particularly substantive changes from the first edition:

- The number of outcomes was increased from 15 to 24. To some extent, this increase reflects the BOK2 authors' attempt to enhance clarity and specificity, rather than to increase the scope of the BOK. Nonetheless, the BOK2 Outcomes do place increased emphasis on such topics as the natural sciences, the humanities, sustainability, globalization, risk and uncertainty, and public policy.
- The BOK2 uses Bloom's Taxonomy as the basis for defining levels of achievement. The fundamental premise of Bloom's Taxonomy is that an educational objective can be referenced to a specific level of cognitive development through the verb used in the objective statement. The use of measurable, action-oriented verbs linked to levels of achievement is beneficial, in that the resulting outcome statements can be assessed more effectively and consistently.

To assess the impact of the BOK on civil engineering curricula and to facilitate broad adoption of the new BOK concepts in civil engineering education, CAP^3 established the BOK Educational Fulfillment Committee (BOKEdFC) in early 2008. This new committee was charged with (1) fostering the creation of a learning community of scholars interested in engineering educational reform, (2) reviewing the work products of the Body of Knowledge Committee and providing feedback, and (3) documenting how programs can incorporate the Body of Knowledge into their curriculum. A key input to this work is the second edition of the *Civil Engineering Body of Knowledge for the 21st Century*. The "companion paper" by Nelson, Fridley, and Hall provides an insight into this committee's work.[25]

The Body of Knowledge Experiential Fulfillment Committee (BOKExFC) was constituted by CAP^3 in the spring of 2009. The committee was charged to develop a stand-alone "Guidelines Document" using the 15 outcomes in the BOK2 with experiential expectations as a basis to be used by civil engineering interns and their mentor/supervisors during the pre-licensure state of the intern's career. The goal is to provide a resource document that interns will find both useful and user friendly in documenting, validating, and reporting their pre-licensure experience activities. The report of this novel group was completed by September 2010. The "companion paper" by Phillips and Holly provides the detailed of this committee's work.[28]

Within NCEES, through the work of the Bachelor's Plus 30 Task Force, the Engineering Education Task Force, and the Uniform Procedures and Legislative Guidelines Committee; challenges to the new NCEES Model Law & Rules from opponents of Raise the Bar were overcome – and necessary refinements were passed by the Council and implementation processes were being planned for the future. In the summer of 2008, the implementation date for the NCEES Model Law & Rules was changed from 2015 to 2020.[26]

The approximate end of this period is marked by another reconfirmation, in April 2010, by the ASCE BOD of its continued support of the Raise the Bar initiative, the CE BOK, and the NCEES recommendations by further refining ASCE Policy 465:

> *ASCE supports the attainment of a Body of Knowledge . . . Fulfillment of this Body of Knowledge will typically include a combination of (1) a baccalaureate*

> *degree in civil engineering; (2) a master's degree, or no less than 30 coordinated graduate or upper level undergraduate technical and/or professional practice credits or the equivalent agency/organization/professional society courses which have been reviewed and approved as providing equal academic quality and rigor with at least 50 percent being engineering in nature; and (3) appropriate experience based upon broad technical and professional practice guidelines which provide sufficient flexibility for a wide range of roles in engineering practice.*

2010 to Present: Consolidating, Communicating, Convincing, and Implementing.
(see Events #41 to #45, Appendix A)

The period since 2010 has been characterized by a re-prioritization of resources within ASCE. After accomplishing the important foundational steps of the Raise the Bar master plan (Vision 2025; Body of Knowledge; BOK-compliant accreditation criteria, curricula, and experiential guidelines; and NCEES Model Law & Rules 2020), ASCE's emphasis was shifted to motivating changes to the engineering licensure statutes. Based upon the extensive research, information resources, insights, and accomplishments of the committees and task committees that have worked on the Raise the Bar initiative between 1998 and 2010, work is underway to overcome the obstacles currently facing two critical actions of the Raise the Bar strategy. The thrust of those two actions can be paraphrased as (1) influence ASCE members, major employers of civil engineers, lead client groups, leaders of engineering organizations, and other key stakeholders to understand and commit to the changes necessary to implement the Raise the Bar initiative and (2) pass changes to the licensing laws in a few states to reflect the NCEES model law and raise the bar for the licensure of engineers. Substantial and significant progress has been made in this phase of the initiative – see http://www.raisethebarforengineering.org.

Summary: 1998 to Present
(see Events #17 to #45, Appendix A)

As previously described, many of the details of these historical events have been captured in the five "companion papers" listed in the second section of this paper. Other primary references related to the Raise the Bar initiative are listed in the bibliography of this paper and its five companion papers. In addition, the authors have identified over 100 papers that have been published on the Raise the Bar initiative since 1998 in the *Proceedings* of the annual conferences of the American Society for Engineering Education (ASEE). A special annotated list of these ASEE proceedings papers is included in Appendix B – sorted by date. All of these papers are available for individual download from http://www.asee.org/search/proceedings.

Who Before What!

ASCE's Raise the Bar initiative could be model case study in support of the conclusions of noted author Jim Collins in his classic study of "Good to Great" enterprises. Paraphrasing his first principle of organizing successful ventures:

First get the right people on the bus
the right people in the right seats,
the wrong people off the bus,
and then figure out where to drive it.

The authors' experience with the Raise the Bar initiative validates Jim Collins' principle. In 1995 the Raise the Bar initiative did not know exactly what direction it would need to take. However, ASCE's and CAP^3's leadership were committed to finding the "right people."

Many of the leaders of the Raise the Bar initiative are listed along with their associated events in Appendix A. The authors believe, for historical reasons, that the dedicated engineering professionals who worked on the various ASCE Raise the Bar committees should be identified. To this end, the authors prepared Appendix C of this paper – consolidated from the various official documents of ASCE. An examination of Appendix C clearly shows that the work to the Raise the Bar for the engineering profession was not accomplished by a small group of reform-minded militants, but a robust group of dedicated, committed, and concerned professionals.

The authors also wish to express their gratitude to the leaders of the American Society of Civil Engineers (listed in Appendix D) for their unfailing support of CAP^3 and its leaders since 1998. The continuity of their support, vision, and leadership was critical to the furthering of the Raise the Bar initiative.

Next Steps

ASCE is undergoing a possible restructuring of their board-level committees. In light of this, there will likely be a repositioning of aspects of the effort to reform civil engineering professional practice. Reform efforts, in the context of implementing the BOK beyond the minimum accreditation criteria, will be on-going. There is an initial plan to consider reviewing the BOK in 2016. In the meantime, the primary focus will be in working with the licensing community with the hope that a few states will increase their educational requirements in the future.

Summary

With an understanding of the reform process used in the Raise the Bar initiative and the activities that have transpired over the last 17 years since the Civil Engineering Education Conference of 1995, the historical context of this effort for civil engineering profession has been documented. This paper, along with the five additional papers published in the series, offer the civil engineering profession a broad and deep understanding of the complexities and interrelationships between education and education reform, a professions' Body of Knowledge, accreditation, licensure, and practical experience. The end goal has been to integrate the complexities and interrelationships into a coordinated effort resulting in meaningful change that improves the profession. This has been achieved as a result of a large number of committed, talented, and focused professionals.

Acknowledgement

The authors wish to express their gratitude to Deb Connor of ASCE and Brad Wigh of the University of Wisconsin–Madison for their assistance with several of the appendices of this paper.

Bibliography

1. Abbott, Andrew. 1988. *The System of Professions: An Essay on the Division of Expert Labor*, Chicago: University of Chicago Press.
2. American Academy of Environmental Engineers. 2009. *Environmental Engineering Body of Knowledge,* AAEE, Annapolis, MD, May.
3. American Society of Civil Engineers. 1995. *Summary Report: 1995 Civil Engineering Education Conference (CEEC '95).* ASCE, Reston, VA.
4. American Society of Civil Engineers. 2001. *Engineering the Future of Civil Engineering.* Report of the Task Committee on the First Professional Degree, ASCE, Reston, VA.
5. American Society of Civil Engineers. 2003. "Moving Toward a Civil Engineering Body of Knowledge for the 21st Century." Report of the Task Committee on Academic Prerequisites for Professional Practice, ASCE, Reston, VA.
6. American Society of Civil Engineers. 2004. "ASCE Policy Statement 465: Academic Prerequisites for Licensure and Professional Practice." ASCE, April.
7. American Society of Civil Engineers. 2004. *Civil Engineering Body of Knowledge for the 21st Century: Preparing the Civil Engineer for the Future,* ASCE, Reston, VA, January.
8. American Society of Civil Engineers. 2006. "Development of Civil Engineering Curricula Supporting the Body of Knowledge for Professional Practice," Report of the Curriculum Committee of the Committee on Academic Prerequisites for Professional Practice. ASCE, December.
9. American Society of Civil Engineers. 2007. *The Vision for Civil Engineering in 2025,* ASCE, Reston, VA.
10. American Society of Civil Engineers. 2008. *Civil Engineering Body of Knowledge for the 21st Century: Preparing the Civil Engineer for the Future – Second Edition,* ASCE, Reston, VA, January.
11. American Society of Civil Engineers. 2009. *Achieving the Vision for Civil Engineering in 2025: A Roadmap for the Profession,* ASCE, Reston, VA.
12. Bella, D. A. 1990. "Existentialism, engineering, and liberal arts." *J.Prof. Issues Eng.*, 116(3), 309–21.

13. Bloom, Benjamin S. 1956. *Taxonomy of Educational Objectives*, Longman, New York, NY.

14. Bordogna, J. 1998. ‘‘Tomorrow’s civil systems engineer—the master integrator.’’ *J. Profl. Issues in Engrg. Educ. and Pract.*, ASCE, 124(2), 48–50.‘‘CE education prodded anew.’’ (1985). ENR, 214(16), 18.

15. Collins, Jim. 2001. *Good to Great*, Harper Collins, New York, NY.

16. Florman, S. C. 1996. ‘‘The whole engineer; role of non-technical subjects in the engineering curricula.’’ *MIT’s Technol. Rev.*, 99(3), 67. Georgia Institute of Technology (GT). (1999). ‘‘Environmental engineering.’’ ^http://www.conted.gatech.edu/distance/enve.html&.

17. Florman, S.C. 1987. *The Civilized Engineer*. St. Martin’s Griffin, New York, NY.

18. Freidson, Eliot. 2001. *Professionalism: The Third Logic—On the Practice of Knowledge*, University of Chicago Press, Chicago, IL.

19. John, W. C. 1930. ‘‘A study of engineering curricula.’’ *Report of the investigation of engineering education, 1923–1929*, Society for the Promotion of Engineering Education, Pittsburgh, 426–521.

20. Krause, E.A. 1996. *Death of the Guilds: Professions, States, and the Advance of Capitalism, 1930 to the Present*. Yale University Press, New Haven, CT.

21. Mann, C. R. 1918. *A study of engineering education, prepared for the Joint Committee on Engineering Education of the National Engineering Societies. Bull. No. 11*, The Carnegie Foundation for the Advancement of Teaching, New York.

22. National Academy of Engineering. 2004. *The Engineer of 2020: Visions of Engineering in the New Century,* NAE, Washington, DC.

23. National Academy of Engineering. 2005. *Educating the Engineer of 2020: Adapting Engineering Education to the New Century,* NAE, Washington, DC.

24. National Resource Council. 1995. *Education of Architects and Engineers for Careers in Facility Design and Construction,* National Academy Press, Washington, DC.

25. Nelson, J.K.; Fridley, K.; and Hall, K. 2012. "The Raise the Bar Initiative: Charting the Future by Understanding the Path to the Present -- How Are BSCE Curricula Responding?" *Proceedings of the 2012 Conference of the American Society for Engineering Education*, June.

26. Nelson, Jon; Musselman, C.; Conzett, M.; and Phillips, M., and Anderson, K. 2012. "The Raise the Bar Initiative: Charting the Future by Understanding the Path to the Present -- Modifying the Model Laws and Rules for Engineering Licensure." *Proceedings of the 2012 Conference of the American Society for Engineering Education*, June.

27. Pauschke, J. M., and Ingraffea, A. R. 1996. ‘‘Recent innovations in undergraduate civil engineering curriculums.’’ *J. Profl. Issues in Engrg. Educ. and Pract.*, ASCE, 122(3), 123–133.

28. Phillips, M. and Holly, F. (2012). "The Raise the Bar Initiative: Charting the Future Through Strengthened Experiential Guidelines." *Proceedings of the 2012 Conference of the American Society for Engineering Education*, June.

29. Rainwater, K., Ramsey, R. H., III, and Thompson, D. B. 1999. ‘‘A five-year master of environmental engineering curriculum.’’ *J. Profl. Issues in Engrg. Educ. and Pract.*, ASCE, 125(2), 40–46.

30. Ressler, S. 2012. "The Raise the Bar Initiative: Charting the Future by Understanding the Path to the Present -- Accreditation Criteria." *Proceedings of the 2012 Conference of the American Society for Engineering Education*, June.

31. Ressler, S.J. 2012. "To Raise the Bar or Not: Addressing the Opposition." *Proceedings of the 2012 Conference of the American Society for Engineering Education*, June.

32. Ressler, S.J. 2007. “An Aspirational Vision of Civil Engineering in 2025—The Role of Accreditation.” *Proceedings of the 2007 Annual Conference of the American Society for Engineering Education*, June.

33. Ressler, S.J. 2008. “Influence of the New Civil Engineering Body of Knowledge on Accreditation Criteria.” *Proceedings of the 2008 Annual Conference of the American Society for Engineering Education*, June.

34. Ressler, S.J. 2010. “Assessing the Standards for Assessment: Is it Time to Update Criterion 3?” *Proceedings of the 2010 Annual Conference of the American Society for Engineering Education*, June.

35. Russell, J. and Lenox, T. 2012. "The Raise the Bar Initiative: Charting the Future by Understanding the Path to the Present -- An Historical Overview." *Proceedings of the 2012 Conference of the American Society for Engineering Education*, June.

36. Russell, J. S., and Stouffer, W. B. 2003a. “Some ethical dimensions of additional education beyond the BSCE.“ *J. Prof. Issues Eng. Educ. Pract.*, 129(4), 225–231.

37. Russell, J. S., and Stouffer, W. B. 2003b. “Too liberal or not liberal enough: Liberal arts, electives, and professional skills.” *Proceedings of the 2003 Conference of the American Society for Engineering Education*, June.

38. Russell, J. S., and Yao, J. T. P. 1996. ‘‘Consensus! Students need more management education.’’ *J. Mgmt. in Engrg.*, ASCE, 12(6), 17–29.

39. Russell, J. S., Stouffer, B., and Walesh, S. G. 2000. ‘‘The first professional degree: A historic opportunity.’’ *J. Profl. Issues in Engrg. Educ. and Pract.*, ASCE, 127(2), 54–63.

40. Russell, J.S., Stouffer, B., and Walesh, S.G. 2001. “Business Case for the Master’s Degree: The Financial Side of the Equation.” *Civil Engineering Education Issues 2001*, Hancher, D.E. (ed.), ASCE Press: Reston, VA, 49-58.

41. Scranton, R. J. 1998. ‘‘Final report of the task committee on civil engineering education initiatives.’’ *Rep. Presented to ASCE Board of Direction*.

42. Walesh, S. 2012. "The BOK and Leadership Lessons Learned." *Proceedings of the 2012 Conference of the American Society for Engineering Education*, June.

43. Walesh, S. G. 2000. ‘‘Engineer our future or others will engineer it for us.’’ *J. Mgmt. in Engrg.*, ASCE, 16(2), 35–41.

44. Wickenden, W. E. 1930. *Report of the investigation of engineering education, 1923–1929*. Society for the Promotion of Engineering Education, Pittsburgh, PA.

Appendix A

Summary and Tabular History of the Raise the Bar Initiative

This appendix includes a history of the Raise the Bar initiative in tabular form. The authors have included most of the significant events directly related to the initiative between 1995 and 2012 in this chronological list. Several other events that indirectly, but significantly, influenced the initiative are also listed. The record (row of table) for each event includes (1) reference number, (2) name of the professional organization(s) leading this event/project, (3) event/project name, (4) short explanatory remarks about the event/project, and (5) names of the primary member and staff leaders of the event/project.

#	Date	Society	Event Name (Abbreviated)	Remarks	Leaders (if applicable)
1	Jun 1995	ASCE	CEEC'95 Held	CEEC'95 = 1995 Civil Engineering Education Conference (Denver, CO) . Conference report made recommendations relative to faculty development, the integrated curriculum, practitioner involvement in the formal educational process, and the first professional degree for entry into professional practice.	Yao, J.T.P. (Chair) Day, C. (Staff)
2	Apr 1996	ASCE	TCCEEI Formed	TCCEEI = Task Committee on Civil Engineering Education Initiatives. One of the first task committees to report directly to the ASCE Board of Direction (BOD). Charged with developing a plan for implementing the outcomes from the CEEC'95. Recommendations in the task committee's April 1998 report led to the BOD's October 1998 adoption of Policy Statement 465.	Scranton, R.J. (Chair) Berman, M.E. (Staff)
3	Apr 1998	ASCE	TCCEEI Report Presented	TCCEEI report recommended to the ASCE Board of Direction (BOD) that the Master's degree be the new First Professional Degree (FPD) for civil engineering.	Scranton, R.J. (Chair) Berman, M.E. (Staff)
4	Oct 1998	ASCE	Policy 465 (Version 1) Passed	Policy 465 = "First Professional Degree." BOD approved new policy recommending the Master’s as the First Professional Degree: "ASCE supports the concept of the Master's degree as First Professional Degree for the practice of civil engineering at a professional level."	Scranton, R.J. (Chair) Kupferman, M. (Staff)

#	Date	Society	Event Name (Abbreviated)	Remarks	Leaders (if applicable)
5	Oct 1999	ASCE	TCFPD Formed	TCFPD = Task Committee on the First Profession Degree. This task committee was formed and charged with developing a vision of the full realization of ASCE Policy 465 (First Professional Degree) -- and a strategy for achieving this vision.	Graef, L.W. (Chair) Kupferman, M. (Staff)
6	Sep 2000	NCEES	ELQTF Formed	ELQTF = Engineering Licensure Qualifications Task Force. Besides NCEES members, task force included membership from American Academy of Environmental Engineers (AAEE), American Society of Mechanical Engineers (ASME), Institute of Electrical and Electronics Engineers–USA (IEEE–USA), American Society of Civil Engineers (ASCE), National Society of Professional Engineers (NSPE), ABET Inc., American Council of Engineering Companies (ACEC), American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE), American Society for Engineering Education (ASEE), ASEE Engineering Deans Council (EDC), and Canadian Engineering Qualifications Board (CEQB).	Nelson, J.D. (Chair); Browne, B., 2000-01; Shannon, M., 2000–03; Adams, J.Q., 2001–03 (Staff)
7	Oct 2001	ASCE	TCFPD Presents Final Report	TCFPD = Task Committee on the First Profession Degree. Final report of the TCFPD recommended the master's or equivalent (MOE) for licensure. Also declared that the practice of CE at the professional level means practice as a licensed professional engineer. Further stated that the admission to the practice of CE at the professional level occurs at licensure, which requires a body of specialized knowledge as reflected by (1) a combination of a baccalaureate degree and a master's or equivalent (MOE), (2) appropriate experience, and (3) commitment to life-long learning.	Graef, L.W. (Chair) Lenox, T.A. (Staff)

#	Date	Society	Event Name (Abbreviated)	Remarks	Leaders (if applicable)
8	Oct 2001	ASCE	Policy 465 (Version 2) Passed	The ASCE Board of Direction adopted Policy Statement 465 which "supports the concept of the master's degree as the First Professional Degree for the practice of civil engineering at the professional level." Name of Policy 465 changed to "Academic Prerequisites for Licensure and Professional Practice."	Graef, L.W. (Chair) Lenox, T.A. (Staff)
9	Oct 2001	ASCE	TCAP^3 Formed	TCAP^3 = Task Committee on the Academic Prerequisites for Professional Practice. The task committee was formed and charged to develop, organize, and execute a detailed plan for the full realization of ASCE Policy Statement 465.	Russell, J.S. (Chair) Lenox, T.A. (Staff)
10	Jan 2002	NSPE	Policy Statement 168 Passed	NSPE Board approved policy statement supporting "the concept of engineering students meeting additional academic requirements as a prerequisite for licensure and practice of engineering at the professional level. Possible additional requirements could include a master's degree or equivalent."	Price, B.E. (Chair) Schwartz, A. (Staff)
11	May 2002	ASCE	BOK1 Committee Formed	BOK1 = Body of Knowledge (1st Edition). The BOK1 Committee was charged to define the Body of Knowledge needed to enter the practice of civil engineering at the professional level (licensure) in the 21st Century.	Walesh, S.G. (Chair) Lenox, T.A. (Staff)
12	Aug 2003	NCEES	ELQTF Report Presented	ELQTF recommended that additional coursework be added to the current bachelor's programs and that the bodies of knowledge required for each program be stipulated. Graduates moving into public practice would supplement their coursework to meet the educational requirements for professional licensure. The task force believed implementation of this concept should be a long-term goal, perhaps occurring over a 15- to 20-year period. Task force members believed that the ultimate goal should be the addition of a professional school to the engineering educational system.	Nelson, J.D. (Chair) Adams, J.Q. (Staff); Shannon, M. (Staff)

#	Date	Society	Event Name (Abbreviated)	Remarks	Leaders (if applicable)
13	Sep 2003	NCEES	LQOG Formed	LQOG = Licensure Qualifications Oversight Group. LQOG established to further explore the findings from the ELQTF report.	Sutherland, W. (Chair: 2003–04); Phillips, M.L. (Chair, 2004–05); Shannon, M. (Staff)
14	Oct 2003	ASCE	CAP^3 Becomes Standing Committee of ASCE	CAP^3 = Committee on the Academic Prerequisites for Professional Practice. Committee was charged to develop, organize, and execute a detailed plan for the full realization of ASCE Policy Statement 465 (Academic Prerequisites for Licensure and Professional Practice). The Committee's activities were to be organized to occur in a concurrent, integrated, and coordinated manner across the broad areas of civil engineering body of knowledge, curriculum development, accreditation, and licensing.	Russell, J.S. (Chair) Lenox, T.A. (Staff)
15	Feb 2004	ASCE	BOK1 Published	BOK1 reported on three themes to meet its charge: (1) what should be taught and learned, (2) how/where it might be taught and learned, and (3) who should teach and learn it. "What should be taught and learned" was expressed as 15 outcomes expressed at three hierarchical levels of achievement (recognition-understanding-ability).	Walesh, S.G. (Chair) Lenox, T.A. (Staff)
16	Feb 2004	ASCE	CAP^3 Accreditation Committee Formed	Committee was charged to develop, organize, and execute a detailed plan for supporting, through the accreditation process, the full realization of ASCE Policy 465 and the associated Civil Engineering Body of Knowledge for the 21st Century.	Bergstrom, W.R. (Chair) Lenox, T.A. (Staff)
17	Apr 2004	NAE	NAE's Engineer of 2020 Published	NAE = National Academy of Engineering. Report envisions the future and uses that knowledge to attempt to predict the roles that engineers will play in the future.	G. Wayne Clough (Chair) Mead, P.F. (Staff)

#	Date	Society	Event Name (Abbreviated)	Remarks	Leaders (if applicable)
18	Oct 2004	ASCE	Policy 465 (Version 3) Passed	BOD approves policy recommending the attainment of a body of knowledge (BOK) for licensure: "ASCE supports attainment of a body of knowledge for entry into the practice of civil engineering at professional level. This would be accomplished through the adoption of appropriate engineering education and experience requirements as a prerequisite for licensure."	Russell, J.S. (Chair) Lenox, T.A. (Staff)
19	Aug 2005	NCEES	LQOG Report Presented	Based upon the LQOG recommendations, the Council approved a motion to increase mandatory engineering education for licensure. As a result, the Uniform Procedures and Legislative Guidelines (UPLG) Committee was charged with recommending revisions to the Model Law to require additional education as a base requirement for P.E. licensure. The committee considered recommended LQOG language, including a provision to raise the current educational requirements by 30 additional hours, and made its recommendations to the Council in 2006. The increased education requirements would be implemented no sooner than 2010.	Phillips, M.L. (Chair) Shannon, M. (Staff)
20	Aug 2005	NCEES	UPLG Charged to Revise Model Law	UPLG = Uniform Procedures and Legislative Guidelines. Committee charged to revise the Model Law to require additional education (see item above).	Baker, C.V. (Chair) Anderson, K. (Staff)
21	Sep 2005	NAE	NAE'S Educating the Engineer of 2020 Published	NAE = National Academy of Engineering. Examined engineering education and asked what it needs to do to prepare individuals to be the engineers of the future. "It is evident that the exploding body of science and engineering knowledge cannot be accommodated within the context of the traditional four-year baccalaureate degree."	G. Wayne Clough (Chair) Taber, R. (Staff)

#	Date	Society	Event Name (Abbreviated)	Remarks	Leaders (if applicable)
22	Oct 2005	ASCE	BOK2 Committee Formed	BOK2 = Body of Knowledge (2nd Edition). The BOK2 Committee was charged to update (if appropriate) the Body of Knowledge needed to enter the practice of civil engineering at the professional level (licensure) in the 21st Century.	Anderson, R. O. (Chair) Lenox, T.A. (Staff)
23	Jun 2006	ASCE	Vision 2025 Summit Held	Diverse group of civil engineering and other leaders, including international guests, gathered to articulate an aspirational global vision for the future of civil engineering addressing all levels and facets of the civil engineering community.	Mongan, D. G. (Chair) Jaeger, S. (Staff)
24	Aug 2006	NCEES	Model Law Changed	Based upon the UPLG recommendations, NCEES members voted to modify the Model Law requirements for licensure to require additional education for engineering licensure no sooner than 2015. The approved language states that an engineer intern with a bachelor's degree must have an additional 30 credits of acceptable upper-level undergraduate or graduate-level coursework from approved providers in order to be admitted to the Principles and Practice of Engineering (PE) examination.	Baker, C.V. (Chair) Anderson, K. (Staff)
25	Apr 2007	ASCE	Policy 465 (Version 4) Passed	BOD refined policy providing more details on the nature of the BOK: "ASCE supports the attainment of a Body of Knowledge . . . The Body of Knowledge includes (1) the fundamentals of math, science, and engineering science, (2) technical breadth, (3) breadth in the humanities and social sciences, (4) professional practice breadth, and (5) technical depth or specialization. Fulfillment of the Body of Knowledge requires additional education beyond the bachelor's degree for the practice of civil engineering at the professional level."	Russell, J.S. (Chair) Lenox, T.A. (Staff)

#	Date	Society	Event Name (Abbreviated)	Remarks	Leaders (if applicable)
26	Aug 2007	NCEES	Model Law Challenged and Model Rules Changed	NCEES voted to reaffirm Model Law changes to "B + 30." UPLG presented motions to revise the Model Rules definitions of Model Law Engineer and Model Law Structural Engineer to include the "B.S. plus 30" requirement. This change made the Model Rules consistent with the Model Law language that member boards passed at the 2006 annual meeting.	Harclerode, H.C. (Chair) Anderson, K. (Staff)
27	Sep 2007	NCEES	B+30TF Formed	B+30TF = Bachelor's +30 Task Force. The task force is charged to clarify the requirements of the new Model Law to allow easier implementation by NCEES Member Boards. Charges included defining approved credits and approved course providers -- and proposing revisions to make the Model Rules consistent with the Model Law concerning the bachelor's plus 30 requirements.	Conzett, M.J. (Chair) Anderson, K. (Staff)
28	Sep 2007	ASCE	Vision 2025 Published	Vision 2025 begins: "Entrusted by society to create a sustainable world and enhance the global quality of life, civil engineers serve competently, collaboratively, and ethically as master . . . "	Mongan, D. G. (Chair) Jaeger, S. (Staff)
29	Oct 2007	ASCE	New Accreditation Criteria Approved	New civil engineering accreditation program criteria (based on BOK1) and new master's level criteria approved by the ABET Board of Directors effective for accreditation reviews beginning in Sep 2008.	Ressler, S. J. (Chair) Lenox, T.A. (Staff)
30	Feb 2008	ASCE	BOK2 Published	BOK2 reported on three themes to meet its charge: (1) the knowledge, skills, and attitudes necessary for entry into professional practice; (2) how/where the BOK2 might be taught and learned relative to the baccalaureate, master's or equivalent, and/or experience; and (3) guidance for faculty, students, engineer interns, and practitioners. "What should be taught and learned" was expressed as 24 outcomes expressed at Bloom's six hierarchical levels of achievement (knowledge-comprehension-application-analysis-synthesis-evaluation).	Anderson, R. O. (Chair) Lenox, T.A. (Staff)

#	Date	Society	Event Name (Abbreviated)	Remarks	Leaders (if applicable)
31	Aug 2008	NCEES	Model Law/Rules Refined	The B+30TF delivered its report and the Council passed each of its three motions. The first motion called for a committee to be charged with exploring the idea of creating a clearinghouse to carry out activities needed to implement the higher education requirement for engineering licensure. The second motion presented language defining the coursework and course providers acceptable in fulfilling the requirement. The third motion addressed whether a degree from an ABET-accredited master's program (M-ABET) should be included in the definition of Model Law Engineer. The motion was to charge the UPLG Committee with incorporating this M-ABET concept into the Model Law/Rules. In a related motion, UPLG proposed a motion to change the implementation date from 2015 to 2020 (passed).	Conzett, M.J. (Chair) Anderson, K. (Staff)
32	Sep 2008	NCEES	B+30TF Renamed as the EETF	EETF = Engineering Education Task Force. The name change for this task committee was partially motivated by the confusion over the focus on the "+30" as a fulfillment path of the required additional formal education. Simultaneous with the name change of the task committee was NCEES's reference to "B + MOE" (Master's or Equivalent) rather than "B + 30."	Conzett, M.J. (Chair) Anderson, K. (Staff)

#	Date	Society	Event Name (Abbreviated)	Remarks	Leaders (if applicable)
33	Oct 2008	ASCE	+30 TC Formed	+30-TC = Plus Thirty Task Committee. Committee was charged to explore what the +30 credits should be and practical alternatives for how civil engineers can attain +30 credits that will be required for licensure as a professional engineer in the future – and that are beyond the requirements of an accredited baccalaureate engineering degree. Specific attention will be focused on alternatives such as corporate universities, public agency professional development programs, professional intensive short courses, and non-engineering degree programs.	Textor, N.G. (Chair) Roth, L. (Staff)
34	Aug 2009	NCEES	Model Law/Rules Refined	EETF successfully moved to proceed with developing a national clearinghouse to assist Member Boards with implementing the education requirement, which will require engineering licensure candidates to obtain an MOE. The proposed clearinghouse would assist boards in determining whether candidates meet the new education requirement, with the goal of promoting consistency across jurisdictions as the requirement is implemented. UPLG presented a motion, approved by the Council, incorporating language into the Model Law and Model Rules specifying the terms "approved course providers" and "acceptable coursework" as they pertain to the MOE requirement. Another successful motion incorporated the ABET-accredited master's program category of degree into the Model Law and Model Rules. ABET had previously not accredited engineering programs at both the bachelor's and master's level.	Conzett, M.J. (Chair) Anderson, K. (Staff)

#	Date	Society	Event Name (Abbreviated)	Remarks	Leaders (if applicable)
35	Oct 2009	ASCE	+30 TC Report Presented	+30-TC = Plus Thirty Task Committee. Validated the wording of the NCEES Model Law & Rules for 2020. Reported that attainment of the knowledge to practice at the professional level will require an accredited bachelor's degree plus either an engineering master's degree, or an additional 30 credits or equivalents of higher level professional education. At least 15 of these 30 credits must be technical courses in engineering. Education beyond the bachelor's degree can be delivered by universities or validated, providers including government and corporate entities and distance learning.	Textor, N.G. (Chair) Roth, L. (Staff)
36	Oct 2009	ASCE	TCICS Formed	TCISC = Task Committee on Implementing the Competency Strategy. The committee was charged with developing the coordination and communications strategies necessary to achieve the outcomes articulated within the ASCE Competency Strategy (aka Raise the Bar Strategy).	Rachford, T.M. (Chair) Dinges, C. (Staff)
37	Apr 2010	NSPE	Position Statement 1752 Passed	NSPE Board approved position statement related to "Engineering Education Outcomes." PS-1752 states that engineering students of all disciplines who become licensed professional engineers should attain education outcomes in addition to those already included in the ABET baccalaureate level general criteria. The additional outcomes include the ability to (1) apply principles of leadership, (2) account for risk and uncertainty in the solution of engineering problems, (3) apply principles of project management, (4) explain where and how public policy is developed and how it influences engineering practice, (5) explain business concepts applicable to engineering practice, and (6) apply principles of sustainability to the design and evaluation of engineering systems.	Musselman, C.N. (Chair) Schwartz, A. (Staff)

#	Date	Society	Event Name (Abbreviated)	Remarks	Leaders (if applicable)
38	Aug 2010	NCEES	ALPTF Formed	ALPTF = Alternate Licensure Pathway Task Force. ALPTF was created to address the second motion of the Engineering Education Task Force from the August 2010 annual meeting. The motion was to investigate an alternate pathway to initial licensure that would allow a combination of assessed learning days and structured mentoring.	Liles, H.V. (Chair) Anderson, K. (Staff)
39	Aug 2010	NCEES	Model Law/Rules Refined	EETF was continued until August 2010 to address potential alternative pathways to licensure. Two alternatives were proposed for consideration at the 2010 NCEES annual meeting. One reflected bachelor degree programs that require 150 or more credit hours and met certain requirements for content. This alternative actually reflects some existing bachelor programs, specifically some in architectural engineering. EETF successfully moved to have UPLG include this pathway into the Model Law and Model Rules. EETF made a second successful motion related to a possible pathway requiring the completion of some number of “assessed learning days” (ALD) of continuing education plus six years of progressive experience. The intent of this alternative was to reflect the different nature of education acquired by engineers who work in industry. EETF successfully moved to pass this alternative on to another committee (see "ALPTF" below) for further study.	Conzett, M.J. (Chair) Anderson, K. (Staff)

#	Date	Society	Event Name (Abbreviated)	Remarks	Leaders (if applicable)
40	Oct 2010	ASCE	Policy 465 (Version 5) Passed	BOD refines policy providing more details on the fulfillment of the BOK (to align with the NCEES Model Law & Rules and the report of the ASCE Plus 30 TC): "ASCE supports the attainment of a Body of Knowledge . . . Fulfillment of this Body of Knowledge will typically include a combination of (1) a baccalaureate degree in civil engineering; (2) a master's degree, or no less than 30 coordinated graduate or upper level undergraduate technical and/or professional practice credits or the equivalent agency/organization/professional society courses which have been reviewed and approved as providing equal academic quality and rigor with at least 50 percent being engineering in nature; and (3) appropriate experience based upon broad technical and professional practice guidelines which provide sufficient flexibility for a wide range of roles in engineering practice."	Russell, J.S. (Chair) Lenox, T.A. (Staff)
41	Oct 2010	ASCE	TCICS Report Presented	TCISC = Task Committee on Implementing the Competency Strategy. The task committee's major effort was devoted to selecting and guiding a communications consultant on the development of the communications plan presented in its report.	Rachford, T.M. (Chair) Dinges, C. (Staff)

#	Date	Society	Event Name (Abbreviated)	Remarks	Leaders (if applicable)
42	Jan 2011	ASCE	TCICS2 Formed	TCISC2 = Task Committee on Implementing the Competency Strategy - Two. The committee was charged to build on the extensive research, information resources, insights, and accomplishments of the committees and task committees that have worked on the Raise the Bar initiative and develop a plan to overcome the obstacles currently facing two key Competency Strategy actions. The thrust of those two actions can be paraphrased as (1) influence ASCE members, major employers of civil engineers, lead client groups, leaders of engineering organizations, and other key stakeholders to understand and commit to the changes necessary to implement the Raise the Bar initiative and (2) pass changes to the licensing laws in a few states to reflect the NCEES model law and raise the bar for the licensure of engineers.	Leonard, B.D. (Chair) Jaeger, S.A. (Staff)
43	Aug 2011	NCEES	ALPTF Report Presented	ALPTF = Alternate Licensure Pathway Task Force. The task force presented its findings as a motion for Council action at the 2011 annual meeting. The motion did not pass.	Liles, H.V. (Chair) Anderson, K. (Staff)
44	Aug 2011	NCEES	UPLG Refines Model Law/Rules 2020	UPLG = Uniform Procedures and Legislative Guidelines. UPLG successfully moved to add new Model Law/Rules language creating an authorized fulfillment path for bachelor degree programs that require 150 or more credit hours and meet certain requirements for content.	Liles, H.V. (Chair) Anderson, K. (Staff)
45	Oct 2012	ASCE	Raise the Bar Committee Formed (tentative but probable)	Planning is currently being accomplished to organize a new Raise the Bar Committee within ASCE. It is envisioned that with the formation of this new committee, the efforts of CAP^3 and TCICS2 would be consolidated. At this time, it is not known how the various constituent committees of CAP^3 will be organized within the ASCE committee structure. Planning for this reorganization is scheduled to be completed by Sep 30, 2012.	To Be Determined

Appendix B

ASEE *Proceedings* Papers Directly Related to the Raise the Bar Initiative

The authors have identified approximately 100 papers that have been published on the Raise the Bar initiative since 1998 in the *Proceedings* of the annual conferences of the American Society for Engineering Education (ASEE). All of these ASEE *Proceedings* papers are available for download from http://www.asee.org/search/proceedings. This is a special annotated list of these ASEE proceedings papers – arranged by date (oldest to newest). Each of the papers has also been given a "Topic Category" from the following four classifications:

- Raise the Bar Initiative -- Overview/Concepts
- BOK (via Education and/or Experience)
- Accreditation
- Licensure

****

Adams, E. and Bras, R. (1999). "MIT's Master of Engineering Degree in Civil and Engineering--a first professional degree." Paper# 296. *Proceedings of the 1999 Conference of the American Society for Engineering Education*, June 1999, Charlotte, NC.

[**Topic Category**] Raise the Bar Initiative -- Overview/Concepts

[**Annotation**] After ASCE's policy statement 465 was released supporting the Master's degree as the First Professional Degree for the practice of Civil Engineering at a professional level, MIT's Department of Civil and Environmental Engineering developed a new degree, seeking a unique and different post-baccalaureate experience. This paper summarizes this new degree program based on the authors' experiences with three graduating classes. The authors hope this will become the model of the first professional degree.

Koehn, E. (1999). "Innovative Master's Degree in a Professional Program." Paper# 204. *Proceedings of the 1999 Conference of the American Society for Engineering Education*, June 1999, Charlotte, NC.

[**Topic Category**] Raise the Bar Initiative -- Overview/Concepts

[**Annotation**] This paper summarizes the recommendations of ASCE's Educational Activities Committee for developing a policy for the first professional degree in civil engineering. In order to study alternatives to the ASCE recommendations, this paper investigates the requirements associated with two graduate degrees, Master of Engineering (ME/M.Eng./MEng) and especially the Master of Engineering Management (MEM), which may serve as the first professional degree in an engineering program. The specific credit hours and typical courses required to obtain a particular degree are indicated. In addition, the concept of a Doctor of Engineering degree (Engr. D.) is also introduced.

Adams, C.; Fitch, M.; and Burken, J. (2000). "Military on Campus: A Joint UMR-Army Program Providing Non-Traditional Master's Degrees.." Paper# 422. *Proceedings of the 2000 Conference of the American Society for Engineering Education*, June 2000, St. Louis, MO.

[**Topic Category**] Raise the Bar Initiative -- Overview/Concepts

[**Annotation**] This paper summarizes the efforts of the University of Missouri-Rolla's Environmental Engineering Program to bring non-traditional students into the classroom by developing a program to offer Master's degrees to US Army Officers completing the Engineering Officer's Advanced Course (EOAC) at Fort Leonard Wood.

Koehn, E. (2000). "Assessment of First Professional Degree Criteria." Paper# 30. *Proceedings of the 2000 Conference of the American Society for Engineering Education*, June 2000, St. Louis, MO.
[**Topic Category**] Raise the Bar Initiative -- Overview/Concepts
[**Annotation**] This paper presents the results of an investigation involving the perceptions of a group of undergraduate and graduate students as well as practicing engineers concerning the ASCE first professional degree policy statement which supports the concept of the Master's degree as the First Professional Degree for the practice of engineering.

Chinowsky, P. (2001). "Addressing the Management Crisis in Civil Engineering Education." Paper# 15. *Proceedings of the 2001 Conference of the American Society for Engineering Education*, June 2001, Albuquerque, NM.
[**Topic Category**] BOK (via Education and/or Experience)
[**Annotation**] This paper addresses the growing need for Civil Engineering students to be exposed to management topics such as entrepreneurship, financial management, and global economics. The author claims that if the civil engineering industry desires to evolve into a new economy business, industry professionals must be as comfortable with the financial and technology components of the business as they are with design or construction fundamentals. The author calls for a new mindset and approach to engineering education in order for universities to develop individuals who have the capability to succeed in the challenging technical business world in which they operate.

Epstein, H. (2002). "ASCE Policy Statement on The First Professional Degree: Where Does it Stand?." Paper# 1020. *Proceedings of the 2002 Conference of the American Society for Engineering Education*, June 2002, Montreal, Quebec.
[**Topic Category**] Raise the Bar Initiative -- Overview/Concepts
[**Annotation**] The primary purpose of this paper is to present the chronology of events and the current status of the issue of the first professional degree in civil engineering.

Russell, J.; Stouffer, B.; Walesh, S.; and Anderson, R.; Price, B.; DeSoto-Duncan, A.; Maples, B.; Buehring, N.; Galloway, G.; Lenox, T.; Esslinger, J, Durrant, J.; and Parsons B. (2002). "Why Raise the Education Bar for Civil Engineers?." Paper# 1071. *Proceedings of the 2002 Conference of the American Society for Engineering Education*, June 2002, Montreal, Quebec.
[**Topic Category**] Raise the Bar Initiative -- Overview/Concepts
[**Annotation**] The purpose of this paper is to better define six of the nine broad issues developed by the ASCE Task Committee on the First Professional Degree necessitating an increase in engineering education. The six issues defined are leadership preparation, broader formal education, professional skills development, appeal to youth, management by non-engineers, and changing systems. This increase in education is in reference to Policy Statement 465 and ASCE's support of the concept of the Master's degree or equivalent as a prerequisite for licensure and the practice of civil engineering at a professional level

Walesh, S. (2002). "Implementing ASCE's "Masters" Policy." Paper# 1084. *Proceedings of the 2002 Conference of the American Society for Engineering Education*, June 2002, Montreal, Quebec.
[**Topic Category**] Raise the Bar Initiative -- Overview/Concepts
[**Annotation**] Described in this paper is the manner in which ASCE is working with stakeholders to develop, organize, and execute a detailed implementation process for Policy Statement 465 which "supports the concept of the Master's Degree or Equivalent (MOE) as a prerequisite for licensure and the practice of civil engineering at a professional level."

(TCAP^3) (2003). "ASCE'S Raise The Bar Initiative: Master Plan For Implementation." Paper# 952. *Proceedings of the 2003 Conference of the American Society for Engineering Education*, June 2003, Nashville, TN.
[**Topic Category**] Raise the Bar Initiative -- Overview/Concepts
[**Annotation**] The purpose of this paper is to describe the efforts of the Task Committee on Academic Prerequisites for Professional Practice (TCAP^3) and their master plan for the implementation of ASCE's Policy Statement 465

Ghaly, A.; Jewell, T.; and Wolfe, F. (2003). "Perception Versus Reality in Civil Engineering Education Today." Paper# 650. *Proceedings of the 2003 Conference of the American Society for Engineering Education*, June 2003, Nashville, TN.
[**Topic Category**] BOK (via Education and/or Experience)
[**Annotation**] This paper attempts to offer a global view of steps implemented by large and small institutions to modernize their Civil Engineering curricula in an attempt to incorporate advancements in technology in newly structured civil engineering courses. The author presents a self-assessed degree of success of these changes, and the level of acceptance these newly revamped programs received.

Nelson, J.K.; Abudayyeh, O.; Tsang, E.; and Williams, M. (2003). "A Civil Engineering Curriculum for the 21st Century." Paper# 696. *Proceedings of the 2003 Conference of the American Society for Engineering Education*, June 2003, Nashville, TN.
[**Topic Category**] BOK (via Education and/or Experience)
[**Annotation**] This paper presents a new Civil Engineering curriculum used at Western Michigan University in response to the ways in which technology has changed the engineering design process and the skills needed for engineering graduates to successfully enter the work force.

Nixon, W. and Bhatti, M. (2003). "A Methodology to Define the Body of Knowledge in Civil Engineering." Paper# 318. *Proceedings of the 2003 Conference of the American Society for Engineering Education*, June 2003, Nashville, TN.
[**Topic Category**] BOK (via Education and/or Experience)
[**Annotation**] This paper will explore, for a particular subdiscipline within civil engineering (structures), how the Body of Knowledge, defined in ASCE's Policy Statement 465, should be developed and of what it might consist at both graduation and licensure levels.

Smerdon, E.; Anderson, R.; and Russell, J. (2003). "ASCE's Raise the Bar Initiative: Accreditation-Related Barriers and Critical Issues." Paper# 1294. *Proceedings of the 2003 Conference of the American Society for Engineering Education*, June 2003, Nashville, TN.
[**Topic Category**] Accreditation
[**Annotation**] This paper describes ASCE's efforts to develop a consensus on the Body of Knowledge that is needed for the practice of Civil Engineering at the professional level. The authors discuss a push for ABET and the EAC to allow institutions the opportunity to obtain accreditation of engineering programs at both the master's and baccalaureate level. The authors believe that allowing dual level accreditation would promote students to continue their education through advanced degrees, thus expanding their Body of Knowledge, and would allow the attainment of such degrees to serve as partial fulfillment of the requirements for licensure.

Walesh, S. (2003). "ASCE's Raise the Bar Initiative: The Body of Knowledge for the Future." Paper# 113. *Proceedings of the 2003 Conference of the American Society for Engineering Education*, June 2003, Nashville, TN.
[**Topic Category**] BOK (via Education and/or Experience)
[**Annotation**] ASCE's Task Committee on Academic Prerequisites for Professional Practice (TCAP^3) was charged to develop, organize, and execute a detailed plan for the full implementation of ASCE Policy 465 (Academic Prerequisites for Licensure and Professional Practice). This paper presents the recommendations of the TCAP^3's Body of Knowledge-Curricula Committee and, secondarily, describes the process used to arrive at those draft recommendations.

Kolar, R.; Knox, R.; Miller, G.; and Muraleetharan. K.; and Sabatini, D. (2004). "An Assessment of How the Sooner City Project Addresses ASCE's Body of Knowledge." Paper# 240. *Proceedings of the 2004 Conference of the American Society for Engineering Education*, June 2004, Salt Lake City, UT.
[**Topic Category**] BOK (via Education and/or Experience)
[**Annotation**] This paper examines the University of Oklahoma's efforts to incorporate the Body of Knowledge that all students should possess in order to enter the practice of the Civil Engineering (as outlined in ASCE's Policy Statement 465) into their curriculum. This curriculum reform project called Sooner City began in 1996 at the University of Oklahoma and the author outlines the ways in which the Sooner City-based curriculum meets the BOK outcomes.

Massie, W. (2004). "Justifying a Body of Knowledge." Paper# 979. *Proceedings of the 2004 Conference of the American Society for Engineering Education*, June 2004, Salt Lake City, UT.
[**Topic Category**] BOK (via Education and/or Experience)
[**Annotation**] This paper describes the recent discussion on the credentials required of Civil Engineers and the Body of Knowledge needed to practice professionally. The author uses his experience with the Delft University of Technology's Civil Engineering curriculum to define the knowledge and skills needed by engineers to be successful in the professional world.

Robinson, M. and Sutterer, K. (2004). "The ASCE BOK – A Case Study of the Evaluation and Design of a BOK Curriculum." Paper# 222. *Proceedings of the 2004 Conference of the American Society for Engineering Education*, June 2004, Salt Lake City, UT.

[**Topic Category**] BOK (via Education and/or Experience)
[**Annotation**] This paper describes the Rose-Hulman Institute of Technology's efforts to evaluate and modify their civil engineering curriculum based on ASCE's Policy Statement 465 and the description of the Body of Knowledge as a means of providing educational requirements appropriate for professional licensure.

Siller, T.J. and Johnson, G. (2004). "Constituent Influences on Engineering Curricula." Paper# 468. *Proceedings of the 2004 Conference of the American Society for Engineering Education*, June 2004, Salt Lake City, UT.
[**Topic Category**] BOK (via Education and/or Experience)
[**Annotation**] This paper provides an overview of the changes made to the engineering curriculum in the United States. The paper focuses on showing the relative shift from an emphasis on purely analytical course work to curricula that emphasize design as well as social aspects of engineering including communication, business practices, and leadership.

Siller, T.J.; Criswell, M.; Fontane, D.; and Grigg, N. (2004). "Some Methods to Achieve Changes in Delivered Civil Engineering Body of Knowledge." Paper# 561. *Proceedings of the 2004 Conference of the American Society for Engineering Education*, June 2004, Salt Lake City, UT.
[**Topic Category**] BOK (via Education and/or Experience)
[**Annotation**] This paper describes the ongoing effort of Colorado State University's Civil Engineering Department to update their curriculum to meet the career needs of future civil engineers. The paper outlines three program features at CSU facilitating the curricular changes needed to achieve consistency with the desired BOK in their undergraduate program. These features include an integrated sequence of eight core courses in which many topics to be developed "across the curriculum" are emphasized, an ongoing planning effort to integrate IT topics into a combination of new or reorganized required and elective courses, and a recently implemented practice-oriented Masters of Engineering program.

Walesh, S. (2004). "From Civil Engineering Body of Knowledge To Civil Engineering Curricula." Paper# 341. *Proceedings of the 2004 Conference of the American Society for Engineering Education*, June 2004, Salt Lake City, UT.
[**Topic Category**] BOK (via Education and/or Experience)
[**Annotation**] This paper presents the recommendations of ASCE's Task Committee on Academic Prerequisites for Professional Practice's Body of Knowledge (BOK) Committee. The paper introduces the subsequent Civil Engineering curricula design effort to ensure that graduating engineers have the appropriate BOK for the professional world.

Dennis, N. and Larson, D. (2005). "Who Should Teach the Civil Engineering "Body of Knowledge?"." Paper# 511. *Proceedings of the 2005 Conference of the American Society for Engineering Education*, June 2005, Portland, OR.
[**Topic Category**] BOK (via Education and/or Experience)
[**Annotation**] This paper describes the current efforts by ASCE's Committee on Faculty Development to define who should teach ASCE's body of knowledge that needs to be addressed in Civil Engineering Programs that lead to a professional degree. The discussion focuses on

faculty credentials, methods of content delivery, and venue of programs, e.g., in-residence versus distance education programs.

Estes, A.; Welch, R.; and Meyer, K. (2005). "Will Ten Pounds Fit into a Five Pound Bag?." Paper# 299. *Proceedings of the 2005 Conference of the American Society for Engineering Education*, June 2005, Portland, OR.
[**Topic Category**] BOK (via Education and/or Experience)
[**Annotation**] The purpose of this paper is to provide an initial assessment on how well the current West Point Civil Engineering program meets the broad based, Body of Knowledge breadth requirements expressed by ASCE (2004b).

Houghtalen, R. (2005). "Can ASCE Cover the “E” in the MOE?." Paper# 121. *Proceedings of the 2005 Conference of the American Society for Engineering Education*, June 2005, Portland, OR.
[**Topic Category**] BOK (via Education and/or Experience)
[**Annotation**] This paper reviews the Body of Knowledge (BOK) proposed for future licensure that will be required beyond the BS degree. The proposed BOK includes not only a Bachelor's degree but a Master's degree or equivalent. The paper describes possible ways for engineers to obtain the "or equivalent" portion of the advanced education ASCE deems necessary for professional licensure.

Koehn, E. and Tohme, H. (2005). "Body of Knowledge: Ethical Responsibility in Engineering and Construction Education and National/Global Professional Bidding Practice." Paper# 1211. *Proceedings of the 2005 Conference of the American Society for Engineering Education*, June 2005, Portland, OR.
[**Topic Category**] BOK (via Education and/or Experience)
[**Annotation**] An international task force has been established to fight the problem of unethical activity occurring in engineering and construction firms in certain areas throughout the world. This paper reviews and investigates the level of corruption at the national/international level and presents a concept that may explain why this corruption is occurring. The paper also presents two solutions to solve the problem of corruption and unethical business practices.

Ressler, S. (2005). "New Accreditation Criteria for the Civil Engineering Profession: Process and Products." Paper# 1217. *Proceedings of the 2005 Conference of the American Society for Engineering Education*, June 2005, Portland, OR.
[**Topic Category**] Accreditation
[**Annotation**] This paper describes the ongoing development of new ABET accreditation criteria for civil engineering programs based on ASCE’s Policy 465 detailing the Civil Engineering Body of Knowledge required of professional engineers. This paper summarizes the evolution of the Body of Knowledge, discusses advantages and limitations of using accreditation criteria as a means of implementing the Body of Knowledge, and provides a detailed description of the proposed, BOK-compliant, accreditation criteria. The ultimate purpose of the paper is to share the new draft criteria with a broader audience to solicit feedback.

Robinson, M. and Sutterer, K. (2005). "The Design of a Four-Year ASCE BOK Compliant Program Tract." Paper# 477. *Proceedings of the 2005 Conference of the American Society for Engineering Education*, June 2005, Portland, OR.

[**Topic Category**] BOK (via Education and/or Experience)

[**Annotation**] ASCE's Body of Knowledge has 15 defined program outcomes, the twelfth being the ability to apply knowledge in a specialized area related to civil engineering. This paper describes the Rose-Hulman Institute of Technology's efforts to incorporate this outcome into their existing civil engineering curriculum.

Schmucker, D. (2005). "Real Engineering Practice In The Classroom: Can ASCE'S BOK Be Done In 4 Years?." Paper# 185. *Proceedings of the 2005 Conference of the American Society for Engineering Education*, June 2005, Portland, OR.

[**Topic Category**] BOK (via Education and/or Experience)

[**Annotation**] The paper briefly discusses how the baccalaureate Civil Engineering program at Western Kentucky University (WKU) was developed in the context of ABET's EC2000, how it compares to ASCE's BOK, and the performance of students. In particular, the authors explore to what degree the joint program between WKU and the University of Kentucky accomplishes the major objectives of ASCE's BOK in a project-based, 4-year program.

Varma, V. (2005). "Basic Elements of the 21st Century Body of Knowledge for a Construction Professional: Challenges for Construction Educators." Paper# 1015. *Proceedings of the 2005 Conference of the American Society for Engineering Education*, June 2005, Portland, OR.

[**Topic Category**] BOK (via Education and/or Experience)

[**Annotation**] This paper presents the basic elements of a current four-year educational program for a construction professional, and compares this with an educational program that would be more suited for a future construction professional based on the ASCE's Body of Knowledge and the subsequent curriculum reform of Civil Engineering Departments around the country. This paper presents a proactive approach to developing broad-based knowledge, requisite skills, attitudes, and integrity in future construction graduates. It stresses understanding of issues such as 21st century global business economy, and multi-cultural teams. The paper also lays the foundation for a strong understanding of world cultures, languages, and local practices in the context of international collaboration on construction projects of all sizes.

Koehn, E.; Koehn, J.; and Paleru, S. (2006). "Satisfying Future Body Of Knowledge Outcomes." Paper# 792. *Proceedings of the 2006 Conference of the American Society for Engineering Education*, June 2006, Chicago, IL.

[**Topic Category**] BOK (via Education and/or Experience)

[**Annotation**] This paper summarizes the findings of research conducted to determine which of the BOK criteria are being satisfied by current undergraduate civil engineering curricula. This investigation indicates that almost all the BOK outcomes tend to be perceived by the respondents as being satisfied in the currently existing undergraduate curriculums except one; specialized knowledge. The authors feel obtaining knowledge in a specialized area is found to be difficult to accomplish in an undergraduate program. The paper draws a comparison between the specialized knowledge needed to become a Certified Public Accountant and the specialized knowledge deemed necessary for professional engineering licensure as described in outcome twelve of ASCE's BOK.

Merino, D. (2006). "A Proposed Engineering Management Body Of Knowledge (EMBOK)." Paper# 174. *Proceedings of the 2006 Conference of the American Society for Engineering Education*, June 2006, Chicago, IL.
[**Topic Category**] BOK (via Education and/or Experience)
[**Annotation**] In this paper an Engineering Management Body of Knowledge (EMBoK) is proposed and then used to develop topics and their relative weights which could be used for an Engineering Manager's certification test. The EMBoK definitions are then compared to the Accreditation Board for Engineering and Technology (ABET) and the American Society of Engineering Management (ASEM) criteria for EM programs to determine if there is consistency.

Ressler, S. (2006). "Progress On Raising The Bar — New CE Accreditation Criteria." Paper# 1197. *Proceedings of the 2006 Conference of the American Society for Engineering Education*, June 2006, Chicago, IL.
[**Topic Category**] Accreditation
[**Annotation**] This paper describes the progress made with ASCE's "Raising the Bar" initiative in an effort to change the Civil Engineering accreditation criteria. Based on the ASCE Policy Statement 465 and the associated Body of Knowledge, this paper expands on the advantages and limitations of using accreditation criteria as a means of implementing the Body of Knowledge, emphasizes the changes to the BOK-compliant accreditation criteria originally presented in Paper 1217, and provides a description of the draft criteria submitted to ABET in the Spring of 2006.

Russell, J.; Lenox, T.; Walesh, S.; and Anderson, R.; Galloway G.; Musselman, C.; Bergstrom, W.; Nelson, J.K.; and O'Brien, J. (2006). "2006-110: Progress On Raising The Bar – Current Progress And Anticipated Next Steps." Paper# 110. *Proceedings of the 2006 Conference of the American Society for Engineering Education*, June 2006, Chicago, IL.
[**Topic Category**] Raise the Bar Initiative -- Overview/Concepts
[**Annotation**] The purpose of this paper is to describe the Committee on Academic Prerequisites for Professional Practice's (CAP^3) efforts to implement Policy Statement 465, to describe the progress over the last year (2005), and outline the next steps for implementation.

Smerdon, E.; Ressler, S.; Nelson, J.; and O'Brien, J. (2006). "Progress On Raising The Bar - Issues Related To The Prohibition On Dual-Level Accreditation Of Engineering Programs." Paper# 246. *Proceedings of the 2006 Conference of the American Society for Engineering Education*, June 2006, Chicago, IL.
[**Topic Category**] Accreditation
[**Annotation**] The purpose of this paper is to directly address the principal points of opposition to dual-level accreditation. The authors feel that substantive change is necessary to implement the BOK, and that if civil engineers are to adequately meet the nation's technological challenges of the future, artificial constraints, such as the prohibition of dual level accreditation, must be removed.

Unnamed Author (2006). "Satisfying Body of Knowledge (BOK) Outcomes in an Undergraduate Curriculum." Paper# 761. *Proceedings of the 2006 Conference of the American Society for Engineering Education*, June 2006, Chicago, IL.

[**Topic Category**] BOK (via Education and/or Experience)
[**Annotation**] This paper summarizes the findings of research conducted to determine which of the BOK criteria are being satisfied by current undergraduate civil engineering curricula. This investigation indicates that almost all the BOK outcomes tend to be perceived by the respondents as being satisfied in the currently existing undergraduate curriculums, except one, specialized knowledge. The authors feel obtaining knowledge in a specialized area is found to be difficult to accomplish in an undergraduate program. This paper draws a comparison between the post-baccalaureate education needed to practice law, versus the type of specialized education referenced in outcome twelve of the Civil Engineering Body of Knowledge.

Delatte, N.; Bosela, P.; Rens, K.; and Carper, K.; and Sutterer, K. (2007). "Findings From Workshops On Failure Case Studies In The Civil Engineering And Engineering Mechanics Curriculum." Paper# 783. *Proceedings of the 2007 Conference of the American Society for Engineering Education*, June 2007, Honolulu, HI.
[**Topic Category**] BOK (via Education and/or Experience)
[**Annotation**] This paper summarizes the findings from four workshops held for engineering educators addressing case studies in engineering mechanics, structural engineering, other civil engineering courses, ethics/professional issues/capstone design courses, and forensic engineering/failure analysis courses. The goal of these workshops was to teach educators how to bring forensics and failure case studies into the civil engineering curriculum as a way of offering students valuable insights into associated technical, ethical, and professional issues

Evans, J.; Lynch, D.; and Lange, D. (2007). "The Role Of Humanities And Social Sciences In The
Civil Engineering Body Of Knowledge." Paper# 1373. *Proceedings of the 2007 Conference of the American Society for Engineering Education*, June 2007, Honolulu, HI.
[**Topic Category**] BOK (via Education and/or Experience)
[**Annotation**] This paper summarizes the broad education necessary for 21st century civil engineers to think critically about issues confronting them and develop solutions that are informed not only by math, science, and engineering, but by humanities and social sciences as well; to implement those solutions effectively within real social contexts; and to evaluate them in humanistic as well as technical terms.

Fridley, K. and Anderson, R. (2007). "ASEE 2007 Abstract--CE BOK--FRIDLEY.DOC." Paper# 432. *Proceedings of the 2007 Conference of the American Society for Engineering Education*, June 2007, Honolulu, HI.
[**Topic Category**] BOK (via Education and/or Experience)
[**Annotation**] This paper describes the inclusive process being used to develop the second edition of the BOK expected for the future practice of civil engineering. The author feels that a strong effort is being made to assess existing and evaluate possible new outcomes for inclusion in the second edition of the BOK. The paper presents six levels of Bloom's Taxonomy to clearly define the desired levels of achievement for each BOK technical and professional outcome, and outlines the resulting BOK outcome rubric.

Hains, D.; Evans, M.; and Ressler, S. (2007). "Teaching The BOK ? Challenges for Faculty And Programs." Paper# 2036. *Proceedings of the 2007 Conference of the American Society for Engineering Education*, June 2007, Honolulu, HI.
[**Topic Category**] BOK (via Education and/or Experience)
[**Annotation**] This paper discusses the non-traditional faculty model in the Department of Civil & Mechanical Engineering at the United States Military Academy and how they have modified their program and educated faculty to teach the new BOK. This version of the Body of Knowledge includes 16 technical and 10 professional outcomes. The professional outcomes, which require a modification of the traditional Civil Engineering program, include leadership, teamwork, communication, history and heritage, professional and ethical responsibility, and life-long learning.

Hoadley, P. (2007). "The ASCE BOK And Attitudes Assessment." Paper# 1845. *Proceedings of the 2007 Conference of the American Society for Engineering Education*, June 2007, Honolulu, HI.
[**Topic Category**] BOK (via Education and/or Experience)
[**Annotation**] This paper addresses the definition of ASCE's Body of Knowledge: the "knowledge, skills, and attitudes necessary for an individual to enter the professional practice of civil engineering." The purpose of this paper is to address the "attitudes" portion of the Body of Knowledge, and discus attitude assessment tools that can be used in lieu of the objective means of measuring "knowledge and skills."

Lynch, D.; Kelly, W.; Jha, M.; and Harichandran, R. (2007). "Implementing Sustainability In The Engineering Curriculum: Realizing The ASCE Body Of Knowledge." Paper# 2422. *Proceedings of the 2007 Conference of the American Society for Engineering Education*, June 2007, Honolulu, HI.
[**Topic Category**] BOK (via Education and/or Experience)
[**Annotation**] This paper discusses the emphasis placed on sustainability in the second edition of the ASCE's BOK as an independent technical outcome and has set out specific levels of cognitive achievement required of all engineers prior to licensure. Addressed in this paper are the elements of a university program including the sustainable use of natural resources, sustainable infrastructure, sustainable production of goods and services, and a research agenda.

Maccariella, J. (2007). "The Role Of Adjuncts In Teaching ASCE'S Body Of Knowledge." Paper# 101. *Proceedings of the 2007 Conference of the American Society for Engineering Education*, June 2007, Honolulu, HI.
[**Topic Category**] BOK (via Education and/or Experience)
[**Annotation**] This paper summarizes student evaluations of a two-semester senior design course that was developed and taught by an adjunct faculty member at Rowan University. The author claims that, based on student's feedback, the adjunct instructors' practical experience and knowledge of day-to-day operations of engineering projects effectively supplements the traditional engineering curricula

Mullenax, C. (2007). "The Role Of The Master's Degree Within Engineering Education." Paper# 565. *Proceedings of the 2007 Conference of the American Society for Engineering Education*, June 2007, Honolulu, HI.

[**Topic Category**] Raise the Bar Initiative -- Overview/Concepts
[**Annotation**] There has been debate over the structure of the master's degree and its role in fulfilling an engineer's educational needs as the first professional degree instead of the bachelor's degree. This paper provides a historical perspective of Master's Degrees and shows the trends of granted degrees to the present time. It discusses these trends, broaches the pros and cons of the Master's Degree, discusses current trends in curricula, and assesses the value of the Master's Degree as currently implemented for the engineering practitioner.

Ressler, S. (2007). "An Aspirational Vision Of Civil Engineering In 2025: The Role Of Accreditation." Paper# 643. *Proceedings of the 2007 Conference of the American Society for Engineering Education*, June 2007, Honolulu, HI.
[**Topic Category**] Accreditation
[**Annotation**] This paper presents an analysis of the recently developed vision for civil engineering in 2025, resulting in the identification of likely changes to current ABET accreditation criteria that would be required to pursue the vision. The analysis is based on a model that emerged during the development of BOK-compliant accreditation criteria, in conjunction with the implementation of ASCE Policy 465.

Roberts, M.; Parker, P.; Curras, C.; and Penn, M.; and Anderson, M. (2007). "An Innovative Infrastructure Curriculum For 21ST Century Civil Engineering." Paper# 1085. *Proceedings of the 2007 Conference of the American Society for Engineering Education*, June 2007, Honolulu, HI.
[**Topic Category**] BOK (via Education and/or Experience)
[**Annotation**] This paper summarizes a new civil engineering curriculum implemented at the University of Wisconsin-Platteville (UWP) to create a focus on infrastructure topics and the built environment in addition to the existing civil engineering coursework. The paper provides details on how an infrastructure theme will be infused throughout the curriculum at UWP.

Russell, J.; Galloway, G.; Lenox, T.; and O'Brien, J. (2007). "ASCE Policy 465 ? The Means For Realizing The Aspirational Visions of Civil Engineering In 2025." Paper# 224. *Proceedings of the 2007 Conference of the American Society for Engineering Education*, June 2007, Honolulu, HI.
[**Topic Category**] Raise the Bar Initiative -- Overview/Concepts
[**Annotation**] The purpose of this paper is to discuss ASCE's current plan for implementing Policy Statement 465 and reforming civil engineering education. Included in this plan is the development of a revised Civil Engineering Body of Knowledge (BOK), modified accreditation criteria, improved civil engineering curricula, and licensure issues.

Seagrave, J. (2007). "Interdisciplinary Pedagogy: Using Teams To Teach The BOK." Paper# 389. *Proceedings of the 2007 Conference of the American Society for Engineering Education*, June 2007, Honolulu, HI.
[**Topic Category**] BOK (via Education and/or Experience)
[**Annotation**] This paper considers how the University of Utah approaches the question "who should teach the body of knowledge?" The paper examines interdisciplinary team teaching in Civil and Environmental Engineering. It specifically focuses on the communication related learning outcomes 6, 7, 8, 9, and 15, and how University of Utah employs teaching teams,

including instructors from Communication, Writing, and Engineering in order to accomplish them by following the collaboration in one, department-required, technical communication course over four semesters.

Sutterer, K.; Hanson, J.; and Aidoo, J. (2007). "First Year Engineering Design: Incorporating Leadership Development Into Real Project Experiences." Paper# 2497. *Proceedings of the 2007 Conference of the American Society for Engineering Education*, June 2007, Honolulu, HI.
[**Topic Category**] BOK (via Education and/or Experience)
[**Annotation**] This paper outlines the First Year Engineering Design Course at Rose-Hulman Institute of Technology as a way of incorporating leadership development into the engineering curriculum at the start of the student's undergraduate career.

Unnamed Author (2007). "Comparing Present Outcome Data to that Utilizing Bloom's Taxonomy." Paper# 306. *Proceedings of the 2007 Conference of the American Society for Engineering Education*, June 2007, Honolulu, HI.
[**Topic Category**] BOK (via Education and/or Experience)
[**Annotation**] This paper presents data that indicates civil/construction engineering programs at the bachelor's level may presently be satisfying, to some degree, 14 of the 15 BOK outcomes. The author feels however, that the twelfth outcome, the attainment of specialized knowledge within civil/construction engineering may be difficult to satisfy in a normal undergraduate civil/construction engineering program. This paper presents a way for universities to evaluate and measure the achievement of BOK outcomes and objectives.

Walesh, S.; Chajes, M.; and Mongan, D. (2007). "Civil Engineering In 2025: The Vision And How It Was Developed." Paper# 1233. *Proceedings of the 2007 Conference of the American Society for Engineering Education*, June 2007, Honolulu, HI.
[**Topic Category**] Raise the Bar Initiative -- Overview/Concepts
[**Annotation**] This paper describes the proceedings of the Summit on the Future of Civil Engineering held in 2006. The summit was attended by a highly varied group of civil and other engineers as well as other industry leaders. The goal of the summit was to articulate an aspirational global vision for the future of civil engineering addressing all levels and facets of the civil engineering community, that is, professional (licensed) civil engineers, non-licensed civil engineers, technologists, and technicians.

Welch, R.; Robinson, M.; Glagola, C.; and Nelson, J.K. (2007). "An Aspirational Vision For Civil Engineering In 2025: The BOK And Future Directions For Civil Engineering Curricula." Paper# 950. *Proceedings of the 2007 Conference of the American Society for Engineering Education*, June 2007, Honolulu, HI.
[**Topic Category**] BOK (via Education and/or Experience)
[**Annotation**] The primary topics addressed in the paper are: the current status of civil engineering degree programs in relation to the ASCE BOK, the means to assess that status at an individual institution, strategies for implementing the ASCE BOK into an institution's civil engineering degree programs at comprehensive doctoral institutions as well as undergraduate

focused institutions, and a methodology for the assessment of BOK-compliant civil engineering degree programs

Anderson, R.; Walesh, S.; and Fridley, K. (2008). "The New And Improved Civil Engineering Body Of Knowledge." Paper# 611. *Proceedings of the 2008 Conference of the American Society for Engineering Education*, June 2008, Pittsburgh, PA.
[**Topic Category**] BOK (via Education and/or Experience)
[**Annotation**] This paper discusses the development of a revised Civil Engineering Body of Knowledge by outlining the processes used by ASCE's BOK2 committee, initiated in late 2005, to arrive at a new set of outcomes in three categories, Foundational, Technical, and Professional that all new engineers should possess as they enter the professional world.

Delatte, N. (2008). "Using Failure Case Studies To Address Civil Engineering Program And BOK Criteria." Paper# 532. *Proceedings of the 2008 Conference of the American Society for Engineering Education*, June 2008, Pittsburgh, PA.
[**Topic Category**] BOK (via Education and/or Experience)
[**Annotation**] This paper suggests ways that failure case studies may be used to address Accreditation Board for Engineering and Technology Engineering Accreditation Commission's (ABET EAC) general and civil engineering program specific criteria, as well as Civil Engineering Body of Knowledge (BOK) criteria.

Evans, J. and Lynch, D. (2008). "Foundational Outcomes Of The New Civil Engineering Body Of Knowledge." Paper# 667. *Proceedings of the 2008 Conference of the American Society for Engineering Education*, June 2008, Pittsburgh, PA.
[**Topic Category**] BOK (via Education and/or Experience)
[**Annotation**] The new civil engineering Body of Knowledge (BOK2) identifies three categories of outcomes as follows: Foundational, Technical and Professional. The four Foundational outcomes are Mathematics, Natural Sciences, Humanities and Social Sciences. This paper explores the background, philosophy, intent and goals of the four Foundational outcomes.

Reinhart, D. (2008). "Developing A Body Of Knowledge For Environmental Engineering." Paper# 175. *Proceedings of the 2008 Conference of the American Society for Engineering Education*, June 2008, Pittsburgh, PA.
[**Topic Category**] BOK (via Education and/or Experience)
[**Annotation**] This paper examines the need for the development of an Environmental Engineering Body of Knowledge, modeled after ASCE's second edition of the Civil Engineering Body of Knowledge. The paper discusses meetings held to establish the Environmental BOK and its purpose. The goal of these meetings was to provide a guide for curriculum development and reform, a guide for employers so they know what they are getting when they hire an environmental engineer, and a mechanism to call for specific attributes such as creativity and innovation.

Ressler, S. (2008). "Influence Of The New Civil Engineering Body Of Knowledge On Accreditation Criteria." Paper# 1097. *Proceedings of the 2008 Conference of the American Society for Engineering Education*, June 2008, Pittsburgh, PA.

[**Topic Category**] Accreditation
[**Annotation**] The purpose of this paper is to present an analysis of the ASCE Civil Engineering Body of Knowledge for the 21st Century, Second Edition, (BOK2) from the perspective of accreditation. Specifically, the author proposes a methodology by which potential changes to the ABET Accreditation Criteria are derived from the BOK2 and then prioritized. This paper also presents an analysis of timing and transition issues associated with implementation of the current BOK1-compliant accreditation criteria and any additional changes that might emerge from the BOK2 process.

Russell, J.; Galloway, G.; Lenox, T.; and O'Brien, J. (2008). "ASCE Policy 465 – Progress And Next Steps." Paper# 46. *Proceedings of the 2008 Conference of the American Society for Engineering Education*, June 2008, Pittsburgh, PA.
[**Topic Category**] Raise the Bar Initiative -- Overview/Concepts
[**Annotation**] The purpose of this paper is to discuss ASCE's current plan for implementing civil engineering curriculum reform including: its release of the second edition of the Civil Engineering Body of Knowledge (BOK), modified accreditation criteria, improved civil engineering curricula, refined experience guidelines for engineer interns, and licensure issues.

Arciszewski, T.; Bronzini, M.; and Houck, M. (2009). "Implementing BOK2: A Modular Post-B.S. Civil Engineering Education Program." Paper# 1461. *Proceedings of the 2009 Conference of the American Society for Engineering Education*, June 2009, Austin, TX.
[**Topic Category**] BOK (via Education and/or Experience)
[**Annotation**] ASCE's Civil Engineering Body of Knowledge for the 21st Century (BOK2) specifies 24 educational outcomes deemed necessary for civil engineering graduates to practice at the professional level. This paper outlines the efforts conducted by three professors at George Mason University to develop a post-BS engineering education program to satisfy those outcomes specified in BOK2 that are unattainable at the undergraduate level. The authors present their educational assumptions, the general outline of their new system of courses several examples of new courses, and discuss how industry involvement was obtained to define these new course modules

Bardet, J. and Ragusa, G. (2009). "Analysis Of Body Of Knowledge In Civil Engineering." Paper# 2293. *Proceedings of the 2009 Conference of the American Society for Engineering Education*, June 2009, Austin, TX.
[**Topic Category**] BOK (via Education and/or Experience)
[**Annotation**] This paper examines how the revised version of ASCE's Body of Knowledge, BOK2, applies the concept of learning taxonomy, originally developed by Bloom (1956) and later revised by Anderson and Krathwohl (2001). BOK2, which was developed using Bloom's taxonomy, is examined using Anderson and Krathwohl's revised learning taxonomy as a guide.

Barry, B.; Mehta, Y.; and St. Clair, S. (2009). "Professional Engineering Licensure And Professional Experience Among Civil Engineering Faculty: A Multi-Institutional Comparison." Paper# 366. *Proceedings of the 2009 Conference of the American Society for Engineering Education*, June 2009, Austin, TX.
[**Topic Category**] Licensure

[**Annotation**] This paper explores the research question, “Among currently licensed civil engineering faculty members, what are the perceived values of professional experience and of licensure as a professional engineer?” This paper details the research design, implementation of the study, and the results. The author feels that the findings and conclusions of this study will be of interest to a variety of academic and licensure stake-holders, including: civil engineering faculty members (both licensed and unlicensed), academic administrators, and licensing organizations such as the National Council of Examiners for Engineering and Surveying (NCEES).

Bielefeldt, A. (2009). "Mapping An Undergraduate Curriculum Onto The Environmental Engineering Body of Knowledge." Paper# 684. *Proceedings of the 2009 Conference of the American Society for Engineering Education*, June 2009, Austin, TX.
[**Topic Category**] BOK (via Education and/or Experience)
[**Annotation**] This paper discusses the University of Colorado at Boulder's efforts to incorporate the Body of Knowledge for Environmental Engineering into their ABET-accredited Environmental Engineering curriculum. The paper addresses the current shortcomings of their program, and concerns with attempting to meet all of the Body of Knowledge outcomes in a B.S. degree. Instead of trying to focus on covering all possible topics that an Environmental Engineer might need to know in a B.S. degree, the author suggests that a better approach could be to develop critical thinking skills in the students and the ability to teach themselves during their professional careers in the context of life long learning.

Chou, K. and Nykanen, D. (2009). "Bringing Professional Experience Into The Classroom: Faculty Experiences." Paper# 2208. *Proceedings of the 2009 Conference of the American Society for Engineering Education*, June 2009, Austin, TX.
[**Topic Category**] BOK (via Education and/or Experience)
[**Annotation**] In this paper, the authors summarize the benefits of their experience teaching at the university level while at the same time holding professional positions in industry. In addition, the authors offer their perspective as a faculty-engineer and discuss the factors influencing the effectiveness of this “dual” position.

Fridley, K.; Hall, K.; Larson, D.; and Sutterer, K.; Alleman, J.; McManis K.; Bardet, J.P.; Gunnink, B.; List, G.; Smith R.; and Lenox T.A. (2009). "2009-ASEE-ABSTRACT BOKEDFC." Paper# 752. *Proceedings of the 2009 Conference of the American Society for Engineering Education*, June 2009, Austin, TX.
[**Topic Category**] BOK (via Education and/or Experience)
[**Annotation**] The purpose of this paper is to provide the engineering education community with its first formal update from ASCE’s new Body of Knowledge (BOK) Educational Fulfillment Committee. The paper presents survey data illustrating how well programs, in their current design, achieve the educational outcomes of both the first and second editions of the civil engineering BOK.

Hernandez, L. and Vitton, S. (2009). "A New Approach To Soil Mechanics Laboratory Curricula: Incorporating The BOK Into A Workshop-Oriented Laboratory." Paper# 438. *Proceedings of the 2009 Conference of the American Society for Engineering Education*, June 2009, Austin, TX.

[**Topic Category**] BOK (via Education and/or Experience)
[**Annotation**] This paper presents an educational model developed to integrate twelve of the twenty-four BOK learning outcomes into the soil mechanics laboratory within the civil engineering curriculum. The model utilizes the cognitive domain of Bloom's Taxonomy to create a workshop-orientated laboratory that enhances student learning. The authors feel that this workshop model will help equip engineering students with the critical thinking, problem solving and technical communication skills needed in the 21st century.

Meyer, F. and Ressler, S. (2009). "Let's Get Down To Business: Preparation For ABET Under The New CE Program Criteria." Paper# 2105. *Proceedings of the 2009 Conference of the American Society for Engineering Education*, June 2009, Austin, TX.
[**Topic Category**] Accreditation
[**Annotation**] ABET accreditation criteria for Civil Engineering Programs underwent major changes prior to the 2008-2009 accreditation cycle. This paper, written by Meyer and Ressler from the United States Military Academy, provides lessons learned from the preparation for an ABET visit at the USMA that occurred during the Fall of 2008 under the newly revised ABET and CE Program Criteria.

Musselman, C. (2009). "Requiring A Master's Degree Or Its Equivalent As A Model Law Prerequisite For Licensure After 2020." Paper# 1864. *Proceedings of the 2009 Conference of the American Society for Engineering Education*, June 2009, Austin, TX.
[**Topic Category**] Licensure
[**Annotation**] This paper presents the modifications and rationale behind changes to the Model Law by the National Council of Examiners of Engineers and Surveyors (NCEES) for the licensure of Professional Engineers requiring an increase in educational qualifications beyond a Bachelor's Degree. The current status of on-going deliberations regarding implementation details is also discussed.

Nelson, E.; Williams, G.; Richards, P.; and Schulz, G.; Wight, T.; and Armstrong, J. (2009). "Assessing State Engineering Examining Boards And Higher Education's Response To The 2006 NCEES Model Law For Professional Engineering Licensure ." Paper# 1501. *Proceedings of the 2009 Conference of the American Society for Engineering Education*, June 2009, Austin, TX.
[**Topic Category**] Licensure
[**Annotation**] The purpose of this paper is to summarize the results of a survey conducted by the graduate committee in the Department of Civil and Environmental Engineering at Brigham Young University (BYU) to ascertain if civil engineering departments at other universities were making changes in their programs and if they were taking planning actions based on the proposed changes to licensing requirements by ASCE and NCEES.

Nelson, Jon; Hornbeck, D.; Lambrechts, J.; and Manous, J.; Stevens, R.; Titus, L.; and Russell, J. (2009). "Paraprofessionals In Civil Engineering." Paper# 884. *Proceedings of the 2009 Conference of the American Society for Engineering Education*, June 2009, Austin, TX.
[**Topic Category**] Raise the Bar Initiative -- Overview/Concepts
[**Annotation**] Paraprofessionals are individuals who have significant engineering educational qualifications and who perform important technical and non-technical roles. This paper summarizes the findings of ASCE's Paraprofessional Exploratory Task Committee (PETC), and

addresses questions regarding paraprofessionals' credentials and the structure of their roles these individuals play in the civil engineering profession.

Ressler, S. and Russell, J. (2009). "The Sociology Of Professions: Application To Civil Engineering." Paper# 686. *Proceedings of the 2009 Conference of the American Society for Engineering Education*, June 2009, Austin, TX.
[**Topic Category**] Raise the Bar Initiative -- Overview/Concepts
[**Annotation**] This paper applies the sociological theory of professions, as espoused by Abbott and Freidson, as a conceptual framework to assess the critical issues associated with the ongoing American Society of Civil Engineers' (ASCE) Policy Statement 465 initiative.

Russell, J.; Galloway, G.; Lenox, T.; and O'Brien, J. (2009). "ASCE Policy 465: Status And Next Steps." Paper# 42. *Proceedings of the 2009 Conference of the American Society for Engineering Education*, June 2009, Austin, TX.
[**Topic Category**] Raise the Bar Initiative -- Overview/Concepts
[**Annotation**] The purpose of this paper is to discuss ASCE's current plan for implementing Policy Statement 465.

Saliklis, E.; Arens, R.; and Hanus, J. (2009). "Teaching Architects And Engineers: Up And Down The Taxonomy." Paper# 2. *Proceedings of the 2009 Conference of the American Society for Engineering Education*, June 2009, Austin, TX.
[**Topic Category**] BOK (via Education and/or Experience)
[**Annotation**] The paper's hypothesis is that Engineering faculty typically move up Bloom's taxonomy of the cognitive domain, whereas Architecture faculty typically move down the taxonomy. This paper aims to determine how educators can aid students who seek larger global understanding, yet are often discouraged during their preliminary acquisition of knowledge. This thesis is explored by studying the literature surrounding the Cognitive Domain in both Civil Engineering and Architecture and providing suggestions for giving engineering students more opportunities to explore higher levels on Bloom's taxonomy in the undergraduate curriculum.

Sutterer, K. (2009). "Developing A Body Of Knowledge For Civil Engineering Specialization: Geotechnical Engineering ." Paper# 1815. *Proceedings of the 2009 Conference of the American Society for Engineering Education*, June 2009, Austin, TX.
[**Topic Category**] BOK (via Education and/or Experience)
[**Annotation**] The paper presents a systematic process that could be used to assess the appropriate body of knowledge for students seeking technical specialization in geotechnical engineering. The paper supports permitting individual departments to define the appropriate body of knowledge for Technical Specialization, but encourages programs to engage in a systematic process to develop appropriate bodies of knowledge for their civil engineering sub disciplines as a service to their students.

Welch, R. (2009). "Integrating Professional Topics and Engineering Constraints Across The Curriculum ." Paper# 734. *Proceedings of the 2009 Conference of the American Society for Engineering Education*, June 2009, Austin, TX.
[**Topic Category**] BOK (via Education and/or Experience)

[**Annotation**] This paper discusses the way to integrate professional topics into the engineering curriculum throughout a student's undergraduate career. The author claims that topics must be introduced and wrestled with early in the curriculum, sustained through additional application during intermediate years, and engrained through integrated application during senior design.

Welch, R. (2009). "Surviving ABET Under The New Criteria - From The Eyes Of New Chair In A New CE Department." Paper# 733. *Proceedings of the 2009 Conference of the American Society for Engineering Education*, June 2009, Austin, TX.

[**Topic Category**] Accreditation

[**Annotation**] This paper covers the processes, experiences, and lessons learned by a new department chair preparing for an ABET visit for the first time in a brand new department under the new 2008 Civil Engineering (CE) program criteria at the University of Texas at Tyler. The goal of this paper is to not only assist new department chairs and chairs of new departments, but also chairs of well established departments that have had a visit with some type of weakness at the exit statement.

Welker, A. (2009). "Lessons Learned From The Recent Accreditation Cycle." Paper# 1231. *Proceedings of the 2009 Conference of the American Society for Engineering Education*, June 2009, Austin, TX.

[**Topic Category**] Accreditation

[**Annotation**] This paper describes the accreditation of the Civil Engineering program at Villanova University during the fall of 2008. The author, an associate professor in the Department of Civil and Environmental Engineering at Villanova University, discusses the evolution of the assessment process from the accreditation criteria used in 1999 vs. the new accreditation criteria adopted in 2008. The paper discusses the key factors that led to a successful evaluation of the Civil Engineering Program at Villanova University and highlights changes to the Villanova curriculum and outcomes of the new program criteria.

Banzley, S.; Terry, R.; and Hotchkiss, R. (2010). "Achieving Civil Engineering BOK2 Outcomes Of Globalization, Leadership, Professional and Ethical Responsibility and Team Work In A General Education Class." Paper# 239. *Proceedings of the 2010 Conference of the American Society for Engineering Education*, June 2010, Louisville, KY.

[**Topic Category**] BOK (via Education and/or Experience)

[**Annotation**] This paper provides motivation from both the National Academy of Engineering and the American Society of Civil Engineers for engineering educators to provide more content in leadership, professional ethics, knowledge of global technical issues, and a more complete understanding of the world's cultures. The paper continues by describing the university criteria these courses must satisfy to be approved to fulfill both Social Science and Global and Cultural Awareness general education requirements and explains the various course modules that address the Civil Engineering BOK2 outcomes of globalization, leadership, professional and ethical responsibility, and teamwork.

Bielefeldt, A. (2010). "Student Perceptions Of The Civil Engineering Body Of Knowledge." Paper# 351. *Proceedings of the 2010 Conference of the American Society for Engineering Education*, June 2010, Louisville, KY.

[**Topic Category**] BOK (via Education and/or Experience)

[**Annotation**] This paper summarizes student feedback on the revised version of the Body of Knowledge (BOK2) at the University of Colorado at Boulder. Students surveyed were freshmen and seniors, and their responses and commentary are presented in this paper with respect to the adequacy of the curriculum at CU when compared to the outcomes defined in the BOK2.

Doran, M.; Quagliana, C.; Doll, N.; and Russell, J.; and Harrington, G. (2010). "Strengthening The Body Of Knowledge – How Integration Of Practicing Engineers As Adjunct Faculty Can Enhance Educational Outcomes." Paper# 548. *Proceedings of the 2010 Conference of the American Society for Engineering Education*, June 2010, Louisville, KY.
[**Topic Category**] BOK (via Education and/or Experience)
[**Annotation**] The purpose of this paper is to describe why the University of Wisconsin-Madison's Department of Civil & Environmental Engineering has worked to integrate practitioners from multiple disciplines who possess extensive professional practice experience within the faculty team as Adjunct Faculty, how this is being done, and the unique aspects the Adjunct Faculty are contributing to the educational process.

Fridley, K. (2010). "How The Civil Engineering BOK2 Is Being Implemented At The University Of Alabama." Paper# 330. *Proceedings of the 2010 Conference of the American Society for Engineering Education*, June 2010, Louisville, KY.
[**Topic Category**] BOK (via Education and/or Experience)
[**Annotation**] The purpose of this paper is to provide a comprehensive analysis of the University of Alabama's civil engineering curriculum with respect to the second edition of the BOK2, or more specifically the BOK2 outcomes associated with the baccalaureate degree since the BOK2 includes outcomes for baccalaureate and post-baccalaureate formal education as well as pre-licensure experience.

Gunnink, B. (2010). "How The Civil Engineering BOK2 Can Be Implemented At Montana State University." Paper# 964. *Proceedings of the 2010 Conference of the American Society for Engineering Education*, June 2010, Louisville, KY.
[**Topic Category**] BOK (via Education and/or Experience)
[**Annotation**] The purpose of this paper is to provide a comprehensive analysis of Montana State University's Civil Engineering curriculum with respect to the second edition of the Civil Engineering Body of Knowledge for the 21st Century (BOK2), or more specifically the BOK2 outcomes associated with the baccalaureate degree since the BOK2 includes outcomes for baccalaureate and post baccalaureate formal education as well as pre-licensure experience.

Hall, K. (2010). "The Challenge Of Implementing The Civil Engineering BOK2 At [University A]." Paper# 1136. *Proceedings of the 2010 Conference of the American Society for Engineering Education*, June 2010, Louisville, KY.
[**Topic Category**] BOK (via Education and/or Experience)
[**Annotation**] This paper presents a comprehensive analysis of [University A's] civil engineering curriculum with respect to the BOK2 outcomes at the levels of achievement associated with the baccalaureate degree. The author claims the current curriculum addresses, in some fashion, all 24 BOK2 outcomes, however the program only addresses, to the recommended level of achievement, 6 of the 24 BOK2 outcomes; the remaining 18 BOK2 outcomes are not addressed to the specified level of achievement for the baccalaureate level.

Hildreth, J. and Gehrig, B. (2010). "A Body Of Knowledge For The Construction Engineering and Management Discipline ." Paper# 1584. *Proceedings of the 2010 Conference of the American Society for Engineering Education*, June 2010, Louisville, KY.

[**Topic Category**] BOK (via Education and/or Experience)

[**Annotation**] This paper describes the process of defining a Body of Knowledge for Construction Engineering and Management undergraduate degrees. As part of a longitudinal review of the construction curriculum, a BOK regarding the technical aspects of construction management is defined based on a review of the requirements of multiple accrediting bodies. The BOK and the curriculum development process presented are independent of any accreditation body, which allows both to be used by any CM program regardless of current or future accreditation requirements.

Larson, D. and Hewes, J. (2010). "A Possible Civil Engineering BOK2 Curriculum." Paper# 275. *Proceedings of the 2010 Conference of the American Society for Engineering Education*, June 2010, Louisville, KY.

[**Topic Category**] BOK (via Education and/or Experience)

[**Annotation**] The purpose of this paper is threefold: (1) provide an analysis of Northern Arizona University's current undergraduate civil engineering curriculum with respect to the BOK2 with attention given to the challenging outcomes; (2) propose a revised BOK2-orientated curriculum within Northern Arizona University's context; and (3) provide an analysis of that curriculum.

List, G. (2010). "How The Civil Engineering BOK2 Could Be Implemented At NC State." Paper# 1648. *Proceedings of the 2010 Conference of the American Society for Engineering Education*, June 2010, Louisville, KY.

[**Topic Category**] BOK (via Education and/or Experience)

[**Annotation**] This paper discusses the way in which the ASCE's Body of Knowledge, version 2 (BOK2), might be implemented at North Carolina State in its Civil Engineering curriculum as perceived by the department head. More specifically, it examines the BOK2 outcomes that relate to the baccalaureate degree, since the plan for achieving the BOK2 outcomes includes post baccalaureate coursework and pre-licensure experience.

McManis, K. (2010). "How The Civil Engineering BOK2 Can Be Implemented At The University Of Louisiana." Paper# 327. *Proceedings of the 2010 Conference of the American Society for Engineering Education*, June 2010, Louisville, KY.

[**Topic Category**] BOK (via Education and/or Experience)

[**Annotation**] The purpose of this paper is to provide a comprehensive analysis of the University of Louisiana's civil engineering curriculum with respect to the second edition of the Civil Engineering Body of Knowledge for the 21st Century (BOK2), or more specifically the BOK2 outcomes associated with the baccalaureate degree since the BOK2 includes outcomes for baccalaureate and post baccalaureate formal education as well as pre-licensure experience. Specific emphasis is given to those BOK2 outcomes that previous survey data identified as being a challenge for many programs to address within current curricular design.

Nixon, W. (2010). "Using History To Reinforce Ethics and Equilibrium." Paper# 895. *Proceedings of the 2010 Conference of the American Society for Engineering Education*, June 2010, Louisville, KY.
[**Topic Category**] BOK (via Education and/or Experience)
[**Annotation**] This paper explores the value of incorporating outcome 11 of the BOK2, "Analyze the impact of historical and contemporary issues on the identification, formulation, and solution of engineering problems and analyze the impact of engineering solutions on the economy, environment, political landscape, and society" into two classes, Statics and Bridge Engineering, at the University of Iowa.

Ressler, S. (2010). "Assessing The Standards For Assessment: Is It Time To Update Criterion 3?." Paper# 1522. *Proceedings of the 2010 Conference of the American Society for Engineering Education*, June 2010, Louisville, KY.
[**Topic Category**] Accreditation
[**Annotation**] In 2009 the Criteria Committee of the ABET Engineering Accreditation Commission initiated a continuous quality improvement process for its accreditation criteria. The purpose of this paper is to support the EAC Criteria Committee's initiative by providing a preliminary assessment of Criterion 3 outcomes in the context of the strategic direction of the engineering profession. The scope of the paper includes: (1) background on the initial formulation of Criterion 3, (2) a review of recent strategic vision statements that suggest a need for changes to Criterion 3, (3) a discussion of potential barriers to change, and (4) recommendations for aligning Criterion 3 with an emerging consensus about the essential attributes of future engineering professionals.

Rogers, G. (2010). "Continuous Quality Improvement In Engineering Education: Fact Or Fiction?." Paper# 1176. *Proceedings of the 2010 Conference of the American Society for Engineering Education*, June 2010, Louisville, KY.
[**Topic Category**] Accreditation
[**Annotation**] This paper examines how "continuous quality improvement" (CQI) processes should be demonstrated in engineering education and explores some of the common mistakes which can lead to considerable effort on the part of faculty with little evidence that the results are useful in understanding the strengths and weaknesses of student learning.

Sutterer, K. (2010). "The Civil Engineering BOK2 And Challenges To Implementation In A Private Undergraduate Engineering Institute." Paper# 1096. *Proceedings of the 2010 Conference of the American Society for Engineering Education*, June 2010, Louisville, KY.
[**Topic Category**] BOK (via Education and/or Experience)
[**Annotation**] The purpose of this paper is to provide a comprehensive analysis of the civil engineering curriculum at Rose-Hulman Institute of Technology with respect to the second edition of the BOK2 and the outcomes described therein associated with the baccalaureate degree.

Tocco, J. and Carpenter, D. (2010). "Adopting The BOK2: The Quest To Slay The Multi-Headed Hydra." Paper# 667. *Proceedings of the 2010 Conference of the American Society for Engineering Education*, June 2010, Louisville, KY.

[**Topic Category**] BOK (via Education and/or Experience)
[**Annotation**] This paper provides an overview of the challenges faced and the various approaches taken by the Civil Engineering Department at Lawrence Technological University in its mission to integrate the BOK2 into the civil engineering program during the spring of 2008 as part of its annual program objectives/outcomes review process.

Bollo M. and Ventura, C. (2011). "A Model For The Post-Bachelor's Degree Education Of Structural Engineers Through A Collaboration Between Industry and Academia." Paper# 590. *Proceedings of the 2011 Conference of the American Society for Engineering Education*, June 2011, Vancouver, British Columbia.
[**Topic Category**] Raise the Bar Initiative -- Overview/Concepts
[**Annotation**] This paper presents a model developed in British Columbia, Canada, for preparing structural engineers for practice, especially in consulting firms, through a series of courses organized and offered through a collaborative effort between local practicing engineers and university faculty members.

Fridley, K. (2011). "Today's BSCE: A Survey Of Credit Hour Requirements." Paper# 1436. *Proceedings of the 2011 Conference of the American Society for Engineering Education*, June 2011, Vancouver, British Columbia.
[**Topic Category**] Raise the Bar Initiative -- Overview/Concepts
[**Annotation**] The purpose of this paper is to present the results of a survey and analysis of today's civil engineering and closely related curricula in terms of credit hours required for degree. The paper provides a comprehensive description of current degree requirements including both total credit hour requirements for degrees as well as a breakdown of the credit hours required in various major topic areas/categories such as mathematics and basic sciences, general engineering topics, and general education.

Kunberger, T.; Burian, S.; Lutey, W.; and Morse, A.; O'Neill, R.; Sanford-Bernhardt, K.; and Welker, A. (2011). "Twenty-First Century Civil Engineering: An Overview of Who, What, And Where." Paper# 619. *Proceedings of the 2011 Conference of the American Society for Engineering Education*, June 2011, Vancouver, British Columbia.
[**Topic Category**] Raise the Bar Initiative -- Overview/Concepts
[**Annotation**] The primary objective of this paper is to analyze the recent past and current demographics of the civil engineering work force and its sub-disciplines and use the information to draw conclusions on future trends and needs. The paper includes predictions into the next decade on the outlook for civil engineering as a function of location, type of industry, and comparison to other engineering disciplines.

Musselman, C.; Nelson, Jon; and Phillips, M. (2011). "Engineering Licensure Laws And Rules, Today and Tomorrow." Paper# 163. *Proceedings of the 2011 Conference of the American Society for Engineering Education*, June 2011, Vancouver, British Columbia.
[**Topic Category**] Licensure
[**Annotation**] The purpose of this paper is to provide a basic description of engineering licensure in the United States including the education, experience, examination, and continuing professional development qualifications required in order to acquire and maintain a license as a Professional Engineer, now and in the future. The paper also describes the legal context of

engineering licensure, the form and function of state Boards of Licensure of Professional Engineers and selected current topics in engineering licensure.

O'Brien, J.; Wei, C.; and Coward, D. (2011). "What Does The Civil Engineering World Look Like? Let's Show It By The Numbers." Paper# 1453. *Proceedings of the 2011 Conference of the American Society for Engineering Education*, June 2011, Vancouver, British Columbia.
[**Topic Category**] Raise the Bar Initiative -- Overview/Concepts
[**Annotation**] This paper presents the civil and other engineering education enrollment and degree data from 1969 to 2009

Ressler, S. and Lynch, D. (2011). "The Civil Engineering Body Of Knowledge And Accreditation Criteria: A Plan For Long-Term Management Of Change." Paper# 668. *Proceedings of the 2011 Conference of the American Society for Engineering Education*, June 2011, Vancouver, British Columbia.
[**Topic Category**] Accreditation
[**Annotation**] This paper proposes a plan for long-term management of updates to the Civil Engineering BOK and the associated ABET accreditation criteria. In developing this proposal, the authors first summarize the chronological development of the Civil Engineering BOK and its associated accreditation criteria, demonstrate that continuous change is a defining characteristic of any professional BOK, and propose a long-term schedule of future BOK and criteria updates that will ensure the relevance of the BOK while enhancing predictability.

Russell, J.; Rogers, J.; Lenox, T.; and Coward, D. (2011). "Civil Engineering Master's Programs: A Comprehensive Review Of Types And Requirements." Paper# 602. *Proceedings of the 2011 Conference of the American Society for Engineering Education*, June 2011, Vancouver, British Columbia.
[**Topic Category**] Raise the Bar Initiative -- Overview/Concepts
[**Annotation**] This paper provides fundamental, statistical information on domestic civil engineering master's programs based upon a survey of 121 civil engineering departments completed in March 2011. The paper describes the range of existing civil engineering master's programs to include their names, types (research, project, and/or course only), entry requirements, number of credits required for degree, mode of delivery (on-campus vs. off-campus and face-to-face vs. on-line), and areas of specialization.

Nelson, J.K.; Fridley, K.; and Hall, K. (2012). "The Raise the Bar Initiative: Charting the Future by Understanding the Path to the Present -- How Are BSCE Curricula Responding?." Paper# TBD. *Proceedings of the 2012 Conference of the American Society for Engineering Education*, June 2012, San Antonio, TX.
[**Topic Category**] BOK (via Education and/or Experience)
[**Annotation**] This paper provides a review of the recommendations for formal education resulting from the "Raise the Bar" initiative that impact the undergraduate curriculum. The paper evaluates the effectiveness of efforts to implement the recommendations of the Raise the Bar Initiative based on a survey identifying changes made to civil engineering undergraduate curricula in three specific BSCE programs.

Nelson, J.; Musselman, C.; Conzett, M.; and Phillips, M., and Anderson, K. (2012). "The Raise the Bar Initiative: Charting the Future by Understanding the Path to the Present -- Modifying the Model Laws and Rules for Engineering Licensure." Paper# TBD. *Proceedings of the 2012 Conference of the American Society for Engineering Education*, June 2012, San Antonio, TX.
[**Topic Category**] Licensure
[**Annotation**] This paper addresses the process followed by the NCEES to make the modifications to the model laws and rules for engineering licensure.. It describes the history, the lessons learned as perceived by the authors, and the next steps for implementation of the new educational standards. It also includes the experiences, observations, reflections, and opinions of the authors: four individuals who participated in the process of changing the NCEES models.

Phillips, M. and Holly, F. (2012). "The Raise the Bar Initiative: Charting the Future Through Strengthened Experiential Guidelines." Paper# TBD. *Proceedings of the 2012 Conference of the American Society for Engineering Education*, June 2012, San Antonio, TX.
[**Topic Category**] BOK (via Education and/or Experience)
[**Annotation**] This paper provides the engineering education community with a summary of ASCE's Body of Knowledge (BOK) Experiential Fulfillment Committee's (BOKExFC) initial work to improve the pre-licensure attainment of experience outcomes for engineering interns. The paper provides a summary of the BOKExFC activities, and emphasizes the guidance for engineering interns, supervisors, and mentors for documenting, validating, and reporting experience activities during the pre-licensure state of the intern's career.

Ressler, S. (2012). "The Raise the Bar Initiative: Charting the Future by Understanding the Path to the Present -- Accreditation Criteria." Paper# TBD. *Proceedings of the 2012 Conference of the American Society for Engineering Education*, June 2012, San Antonio, TX.
[**Topic Category**] Accreditation
[**Annotation**] This paper (1) summarizes the decade-long process of developing and implementing new accreditation criteria in support of the ASCE Raise the Bar initiative; (2) identifies the principal lessons learned through this process; and (3) provides recommendations for future developments in the accreditation domain of this ongoing effort to raise the educational standard for civil engineering professional practice.

Ressler, S. (2012). "To Raise the Bar or Not: Addressing the Opposition." Paper# TBD. *Proceedings of the 2012 Conference of the American Society for Engineering Education*, June 2012, San Antonio, TX.
[**Topic Category**] Raise the Bar Initiative -- Overview/Concepts
[**Annotation**] This paper assesses the key points of opposition presented in the ASME position paper, "Mandatory Educational Requirements for Engineering Licensure," from two complementary perspectives: (1) validity of each specific point of opposition, based on objective evidence, logic, and recent multi-disciplinary visions of the engineering profession's future; and (2) consistency with the theoretical framework of professionalism as described in the Sociology of Professions.

Russell, J. and Lenox, T. (2012). "The Raise the Bar Initiative: Charting the Future by Understanding the Path to the Present -- An Historical Overview ." Paper# TBD. *Proceedings*

of the 2012 Conference of the American Society for Engineering Education, June 2012, San Antonio, TX.
[**Topic Category**] Raise the Bar Initiative -- Overview/Concepts
[**Annotation**] This paper, the first of the six papers, provides an overall summary of the Raise the Bar Initiative as witnessed and experienced by two of the long-term leaders of CAP^3. The other five papers were written from five different, yet closely related, perspectives including: (1) civil engineering bodies of knowledge, (2) revised accreditation criteria, (3) changed university curricula, (4) experiential guidelines, and (5) modified licensure laws and rules. Much of the summary in this first paper is presented in tabular form, not duplicating the more detailed information written in the other five papers.

Walesh, S. (2012). "A Half Brain is Good: A Whole Brain Much Better." Paper# TBD. *Proceedings of the 2012 Conference of the American Society for Engineering Education*, June 2012, San Antonio, TX.
[**Topic Category**] BOK (via Education and/or Experience)
[**Annotation**] This paper asserts that engineers should be more creative and innovative, and offers ideas on how to enable them to be more creative and innovative. After offering a brief brain primer, the paper introduces tools and techniques which recognize that, while creative and innovative ideas lie within most of us, we need mechanisms to release them within individuals and groups.

Walesh, S. (2012). "The BOK and Leadership Lessons Learned." Paper# TBD. *Proceedings of the 2012 Conference of the American Society for Engineering Education*, June 2012, San Antonio, TX.
[**Topic Category**] BOK (via Education and/or Experience)
[**Annotation**] This paper provides a summary of leadership lessons learned (LLL) from the BOK element of the CAP^3 effort. Given that this paper summarizes LLL primarily from a decade-long major change process, it offers two potentially useful takeaways for the reader. The first is an improved understanding of the BOK and the second is ideas about how to lead any change effort.

Appendix C

List of Selected Individuals Working With ASCE to Raise the Bar

The authors believe, for historical reasons, that the dedicated engineering professionals who worked on the various ASCE Raise the Bar committees should be identified in this paper. To this end, the authors prepared this appendix – consolidated from the various official documents of ASCE. An examination the committee listings clearly shows that the work to the Raise the Bar for the engineering profession was not accomplished by a small group of reform-minded militants, but a robust group of dedicated, committed, and concerned professionals.

The following abbreviations (related to position in committee) are used in the listings below:

C: Chair
M: Member
VC: Vice-Chair
E: Editor
CM: Corresponding Member
SC: ASCE Staff Contact
SL: ASCE Staff Leader
SM: ASCE Staff Member
CCM: CAP3 Contact Member
CSC: CAP3 Staff Contact
EOM: Ex-Offico Member

1993 – 1994

1993-1994: Workshop on Civil Engineering Education Steering Committee

Clinton E. Parker, P.E., F.ASCE (C)
Donald A. Dupies, P.E., F.ASCE (M)
WilliamHighter, Ph.D., P.E., F.ASCE (M)
Guy E. Jester, Ph.D., P.E., F.ASCE (M)
Charles Samson, Ph.D., P.E., F.ASCE (M)
James R. Schaaf, Ph.D., P.E., F.ASCE (M)

1994 – 1995

1994-1995: Civil Engineering Education Conference Steering Committee

James T. P. Yao, Ph.D., P.E. (C)
David S. Gedney, P.E., F.ASCE (M)
William J. Hall, Ph.D., P.E., NAE, Hon.M.ASCE (M)
James P. Heaney, Ph.D., P.E., D.WRE, M.ASCE (M)
Jerry J. Marley, Ph.D., P.E., M.ASCE (M)
William Neuman, Ph.D., P.E., F.ASCE (M)
David A. Novick, P.E. (M)
James W. Poirot, P.E., Pres.94.ASCE (M)
Sandra L. Weber, M. ASCE (M)

1996 – 1998

1996-1998: Task Committee Civil Engineering Education Initiatives (TCCEEI)

Richard J. Scranton, M.ASCE (C)
Rafael L. Bras, Ph.D., P.E., F.ASCE (M)
David S. Gedney, P.E., F.ASCE (M)
Richard Hovey, P.E., F.ASCE (M)

William E. Kelly, P.E., F.ASCE (M)
Daniel J. McGinley (M)
Melvin Ramey, Ph.D., P.E., M.ASCE (M)
Jeffrey S. Russell, Ph.D., P.E., F.ASCE (M)
Marla E. Berman, P.E. (SC)

1999 – 2000

1999-2000: Task Committee on the First Professional Degree (TCFPD)

Luther W. Graef, P.E., Pres.98.ASCE (C)
Richard O. Anderson, P.E., Dist.M.ASCE (M)
Eugene J. Fasullo, P.E., F.ASCE (M)
Gerald E. Galloway, Ph.D., P.E., Hon.D.WRE, Dist.M.ASCE (M)
William E. Kelly, P.E., F.ASCE (M)
Stuart G. Walesh, Ph.D., P.E., D.WRE, Dist.M.ASCE (M)
Thomas A. Lenox, Ph.D., M.ASCE (SM)
Michael Kupferman, P.E., M.ASCE (SL)

2000 - 2001

2000-2001: Task Committee on the First Professional Degree (TCFPD)

Luther W. Graef, P.E., Pres.98.ASCE (C)
Richard O. Anderson, P.E., Dist.M.ASCE (M)
Gerald E. Galloway, Ph.D., P.E., Hon.D.WRE, Dist.M.ASCE (M)
William E. Kelly, P.E., F.ASCE (M)
Melvin R. Ramey, Ph.D., P.E., M.ASCE (M)
Lawrence H. Roth, P.E., M.ASCE (M)
Stuart G. Walesh, Ph.D., P.E., D.WRE, Dist.M.ASCE (M)
Thomas A. Lenox, Ph.D., M.ASCE (SL)

2001 - 2002

2001-2002: Task Cmte on Academic Prerequisites for Professional Practice (TCAP^3)

Jeffrey S. Russell, Ph.D., P.E., F.ASCE (C)
Richard O. Anderson, P.E., Dist.M.ASCE (M)
Norman L. Buehring, P.E., F.ASCE (M)
Gerald E. Galloway, Ph.D., P.E., Hon.D.WRE, Dist.M.ASCE (M)
Stuart G. Walesh, Ph.D., P.E., D.WRE, Dist.M.ASCE (M)
Thomas A. Lenox, Ph.D., M.ASCE (SL)

2002 - 2003

2002-2003: Task Cmte on Academic Prerequisites for Professional Practice (TCAP^3)

Jeffrey S. Russell, Ph.D., P.E., F.ASCE (C)
Stuart G. Walesh, Ph.D., P.E., D.WRE, Dist.M.ASCE (VC)
Richard O. Anderson, P.E., Dist.M.ASCE (M)
Norman L. Buehring, P.E., F.ASCE (M)
Angela Desoto Duncan, P.E., M.ASCE (M)
John E. Durrant, P.E., M.ASCE (M)
Jonathan C. Esslinger, P.E., F.ASCE (M)
Gerald E. Galloway, Ph.D., P.E., Hon.D.WRE, Dist.M.ASCE (M)
C. Gary Kellogg, P.E., S.E., F.ASCE (M)
E. W. LeFevre, Ph.D., P.E., Dist.M.ASCE (M)
Brook A. Maples, P.E., M.ASCE (M)
David G. Mongan, P.E., Pres.08.ASCE (M)
Craig N. Musselman, P.E., Dist.M.ASCE (M)
Thomas A. Lenox, Ph.D., M.ASCE (SL)

2002-2003: TCAP^3 Body of Knowledge

Stuart G. Walesh, Ph.D., P.E., D.WRE, Dist.M.ASCE (C)
Dale W. Sall, P.E., L.S., F.ASCE (VC)
Abbie M. Dement (M)
Gerald E. Galloway, Ph.D., P.E., Hon.D.WRE, Dist.M.ASCE (M)
Chris Hendrickson, Ph.D., Hon.M.ASCE (M)
Ralph J. Hodek, Ph.D., P.E., F.ASCE (M)
John S. Shearer, P.E., M.ASCE (M)
Thomas A. Lenox, Ph.D., M.ASCE (SL)
James J. O'Brien, P.E., M.ASCE (SC)

2002-2003: TCAP^3 Licensing Committee

Craig N. Musselman, P.E., Dist.M.ASCE (C)
Dale W. Sall, P.E., L.S., F.ASCE (VC)
Jonathan C. Esslinger, P.E., F.ASCE (M)
E. W. LeFevre, Ph.D., P.E., Dist.M.ASCE (M)
Bobby E. Price, Ph.D., P.E., Dist.M.ASCE (M)

2002-2003: TCAP^3 Accreditation Committee

Richard O. Anderson, P.E., Dist.M.ASCE (C)
Ernest T. Smerdon, Ph.D., P.E., Dist.M.ASCE, NAE (VC)
Peter J. Carrato, Ph.D., P.E., F.ASCE (M)
John W. Steadman, Ph.D. (M)
Thomas A. Lenox, Ph.D., M.ASCE (SL)

2003 - 2004

2003-2004: Cmte on the Academic Prerequisites for Professional Practice (CAP^3)

Jeffrey S. Russell, Ph.D., P.E., F.ASCE (C)
Stuart G. Walesh, Ph.D., P.E., D.WRE, Dist.M.ASCE (VC)
Richard O. Anderson, P.E., Dist.M.ASCE (M)
H. Edmund Bergeron, P.E., M.ASCE (M)
Norman L. Buehring, P.E., F.ASCE (M)
Gerald E. Galloway, Ph.D., P.E., Hon.D.WRE, Dist.M.ASCE (M)
W. Craig Helms, P.E. (M)
C. Gary Kellogg, P.E., S.E., F.ASCE (M)
Oliver G. McGee (M)
Craig N. Musselman, P.E., Dist.M.ASCE (M)
Debbie A. Niemeier, Ph.D., M.ASCE (M)
Erin E. Peterson, P.E., M.ASCE (M)
Sheina K. Pool (M)
Ernest T. Smerdon, Ph.D., P.E., Dist.M.ASCE, NAE (M)
Thomas A. Lenox, Ph.D., M.ASCE (SL)

2003-2004: CAP^3 Body of Knowledge

Stuart G. Walesh, Ph.D., P.E., D.WRE, Dist.M.ASCE (C)
Michael J. Chajes, Ph.D., P.E. (M)
Abbie M. Dement (M)
Gerald E. Galloway, Ph.D., P.E., Hon.D.WRE, Dist.M.ASCE (M)
Chris Hendrickson, Ph.D., Hon.M.ASCE (M)
Ralph J. Hodek, Ph.D., P.E., F.ASCE (M)
Dale W. Sall, P.E., L.S., F.ASCE (VC)
John S. Shearer, P.E., M.ASCE (M)
Thomas Siller, Ph.D. (M)
John Tawresey, P.E. (M)
Stuart G. Walesh, Ph.D., P.E. (M)
Marlee Ann Walton, P.E., LSI (M)
Thomas A. Lenox, Ph.D., M.ASCE (SL)
James J. O'Brien, P.E., M.ASCE (SM)

2003-2004: CAP^3 BOK Curricula

Stuart G. Walesh, Ph.D., P.E., D.WRE, Dist.M.ASCE (C)
Kevin G. Sutterer, P.E., M.ASCE (M)
Jeffrey C. Evans, Ph.D., P.E., M.ASCE (M)
C. Dale Jacobson, P.E., BCEE, F.ASCE (M)
Young C. Kim (M)
Thomas J. Siller, Ph.D., M.ASCE (M)
James K. Nelson, Ph.D., P.E., F.ASCE (M)
John G. Tawresey, P.E., M.ASCE (M)
Marlee A. Walton, P.E., M.ASCE (M)
Robert L. Mullen, Ph.D., P.E., F.ASCE (M)
Jeffrey S. Russell, Ph.D., P.E., F.ASCE (CCM)
James J. O'Brien, P.E., M.ASCE (SL)

2003-2004: CAP^3 Licensing Committee

Craig N. Musselman, P.E., Dist.M.ASCE (C)
Dale W. Sall, P.E., L.S., F.ASCE (VC)
Walter Marlowe, P.E., M.ASCE (M)
E. W. LeFevre, Ph.D., P.E., Dist.M.ASCE (M)
Bobby E. Price, Ph.D., P.E., Dist.M.ASCE (M)
Walter Marlowe, P.E., M.ASCE (SL)

2003-2004: CAP^3 Accreditation Committee

Richard O. Anderson, P.E., Dist.M.ASCE (C)
Ernest T. Smerdon, Ph.D., P.E., Dist.M.ASCE, NAE (VC)
Peter J. Carrato, Ph.D., P.E., F.ASCE (M)
H. Chik Erzurumlu, Ph.D., P.E., F.ASCE (M)
Maurice C. Mow, Ph.D., P.E., M.ASCE (M)
John W. Steadman, Ph.D. (M)
Thomas A. Lenox, Ph.D., M.ASCE (SL)
James J. O'Brien, P.E., M.ASCE (SM)

2004 – 2005

2004-2005: Cmte on the Academic Prerequisites for Professional Practice (CAP^3)

Jeffrey S. Russell, Ph.D., P.E., F.ASCE (C)
Stuart G. Walesh, Ph.D., P.E., D.WRE, Dist.M.ASCE (VC)
Richard O. Anderson, P.E., Dist.M.ASCE (M)
H. Edmund Bergeron, P.E., M.ASCE (M)
Gerald E. Galloway, Ph.D., P.E., Hon.D.WRE, Dist.M.ASCE (M)
W. Craig Helms, P.E. (M)
E. W. LeFevre, Ph.D., P.E., Dist.M.ASCE (M)
Craig N. Musselman, P.E., Dist.M.ASCE (M)
James K. Nelson, Ph.D., P.E., F.ASCE (M)
Debbie A. Niemeier, Ph.D., M.ASCE (M)
Erin E. Peterson, P.E., M.ASCE (M)
Sheina K. Pool (M)
James R. Schaaf, Ph.D., P.E., F.ASCE (M)
Ernest T. Smerdon, Ph.D., P.E., Dist.M.ASCE, NAE (M)
William A. Welsh, Ph.D., P.E., F.ASCE (M)
N. Catherine Bazan-Arias, Ph.D., P.E., M.ASCE (CM)
Robert C. Krebs, P.E., L.S., F.ASCE (CM)
David R. Martinelli, Ph.D., A.M.ASCE (CM)
Brandon T. Pierce, A.M.ASCE (CM)
John W. Steadman, Ph.D. (CM)
Thomas A. Lenox, Ph.D., M.ASCE (SL)
Walter Marlowe, P.E., M.ASCE (SM)

2004-2005: CAP^3 Accreditation Committee

Wayne R. Bergstrom, Ph.D., P.E., F.ASCE (C)
Stephen J. Ressler, Ph.D., P.E., Dist.M.ASCE (VC)
Peter J. Carrato, Ph.D., P.E., F.ASCE (M)
H. Chik Erzurumlu, Ph.D., P.E., F.ASCE (M)
Ron Harichandran, Ph.D., P.E., F.ASCE (M)
David R. Martinelli, Ph.D., A.M.ASCE (M)
Maurice C. Mow, Ph.D., P.E., M.ASCE (M)
Craig N. Musselman, P.E., Dist.M.ASCE (M)
James K. Nelson, Ph.D., P.E., F.ASCE (M)
John W. Steadman, Ph.D. (M)
Stuart G. Walesh, Ph.D., P.E., D.WRE, Dist.M.ASCE (M)
William A. Welsh, Ph.D., P.E., F.ASCE (M)

Jeffrey S. Russell, Ph.D., P.E., F.ASCE (CCM)
Thomas A. Lenox, Ph.D., M.ASCE (SL)
James J. O'Brien, P.E., M.ASCE (SM)

2004-2005: CAP^3 Curricula

James K. Nelson, Ph.D., P.E., F.ASCE (C)
Thomas J. Siller, Ph.D., M.ASCE (VC)
Thomas J. Descoteaux, P.E., M.ASCE (M)
Jeffrey C. Evans, Ph.D., P.E., M.ASCE (M)
Debra S. Larson, P.E., M.ASCE (M)
Allen Estes, Ph.D., P.E., M.ASCE (M)
Maher Tadros, Ph.D., P.E., M.ASCE (M)
Laurence J. Jacobs, Ph.D., M.ASCE (M)
C. Dale Jacobson, P.E., BCEE, F.ASCE (M)
Young C. Kim (M)
Robert C. Knox, A.M.ASCE (M)
Randall L. Kolar, P.E., M.ASCE (M)
Michael Kupferman, P.E., M.ASCE (M)
Debra S. Larson, P.E., M.ASCE (M)
Arthur C. Miller, Ph.D., P.E., L.S., D.WRE, F.ASCE (M)
Peter Hoadley, Ph.D., P.E., F.ASCE (M)
Gayle F. Mitchell, Ph.D., P.E., M.ASCE (M)
J.P. Mohsen, Ph.D. (M)
Robert L. Mullen, Ph.D., P.E., F.ASCE (M)
Michael A. Robinson (M)
Kevin G. Sutterer, P.E., M.ASCE (M)
John G. Tawresey, P.E., M.ASCE (M)
Stuart G. Walesh, Ph.D., P.E., D.WRE, Dist.M.ASCE (M)
Marlee A. Walton, P.E., M.ASCE (M)
Brian R. Brenner, P.E., M.ASCE (CM)
Edwin R. Schmeckpeper, P.E., M.ASCE (CM)
Jeffrey S. Russell, Ph.D., P.E., F.ASCE (CCM)
Thomas A. Lenox, Ph.D., M.ASCE (CCM)
James J. O'Brien, P.E. (SL)

2004-2005: CAP^3 Licensing Committee

Craig N. Musselman, P.E., Dist.M.ASCE (C)
Dale W. Sall, P.E., L.S., F.ASCE (VC)
E. W. LeFevre, Ph.D., P.E., Dist.M.ASCE (M)
H. Edmund Bergeron, P.E., M.ASCE (M)
Kerry M. Hawkins, P.E., M.ASCE (M)
Brian R. Brenner, P.E., M.ASCE (M)
Kerry M. Hawkins, P.E., M.ASCE (M)
Richard Moore (M)
Bobby E. Price, Ph.D., P.E., Dist.M.ASCE (M)
Jeffrey S. Russell, Ph.D., P.E., F.ASCE (CCM)
Thomas A. Lenox, Ph.D., M.ASCE (CCM)
Walter T. Marlowe, P.E., M.ASCE (SL)

2004-2005: CAP^3 Validation & Fulfillment

Jeffrey S. Russell, Ph.D., P.E., F.ASCE (C)
Stuart G. Walesh, Ph.D., P.E., D.WRE, Dist.M.ASCE (VC)
Gerald E. Galloway, Ph.D., P.E., Hon.D.WRE, Dist.M.ASCE (VC)
Rick Barnaby (M)
H. Edmund Bergeron, P.E., M.ASCE (M)
Mark Brewer (M)
Mary Leslie (M)
James K. Nelson, Ph.D., P.E., F.ASCE (M)
John P. Klus, P.E., M.ASCE (M)
Craig N. Musselman, P.E., Dist.M.ASCE (M)
Robyn S. Colosimo, P.E., F.ASCE (M)
John Casazza, Aff.M.ASCE (M)
Thomas A. Lenox, Ph.D., M.ASCE (CCM)
Walter Marlowe, P.E., M.ASCE (SC)

2005 - 2006

2005-2006: Cmte on the Academic Prerequisites for Professional Practice (CAP^3)

Jeffrey S. Russell, Ph.D., P.E., F.ASCE (C)
Gerald E. Galloway, Ph.D., P.E., Hon.D.WRE, Dist.M.ASCE (VC)
S. G. Walesh, Ph.D., P.E., D.WRE, Dist.M.ASCE (VC)
Reginald L. Amory, Ph.D., P.E., F.ASCE (M)
Richard O. Anderson, P.E., Dist.M.ASCE (C)
N. Catherine Bazan-Arias, Ph.D., P.E., M.ASCE (CM)
Wayne R. Bergstrom, Ph.D., P.E., F.ASCE (C)
Birdel F. Jackson, III, P.E., M.ASCE (M)
Robert C. Krebs, P.E., L.S., F.ASCE (CM)
E. W. LeFevre, Ph.D., P.E., Dist.M.ASCE (M)
David R. Martinelli, Ph.D., A.M.ASCE (M)
Craig N. Musselman, P.E., Dist.M.ASCE (M)
James K. Nelson, Ph.D., P.E., F.ASCE (M)
Sheina K. Pool (M)
Stephen J. Ressler, Ph.D., P.E., Dist.M.ASCE (CM)
James R. Schaaf, Ph.D., P.E., F.ASCE (M)
Ernest Thomas Smerdon, Ph.D., P.E., Dist.M.ASCE, NAE (M)
John W. Steadman, Ph.D. (M)
Thomas A. Lenox, Ph.D., M.ASCE (SL)
Walter T. Marlowe, P.E., M.ASCE (SM)
James J. O'Brien, P.E., M.ASCE (SC)

2005-2006: CAP^3 Accreditation Committee

Wayne R. Bergstrom, Ph.D., P.E., F.ASCE (C)
Stephen Ressler, Ph.D., P.E., Dist.M.ASCE (VC)
Richard O. Anderson, P.E., Dist.M.ASCE (M)
Phillip E. Borrowman, P.E., F.ASCE (M)
Peter J. Carrato, Ph.D., P.E., F.ASCE (M)
H. Chik Erzurumlu, Ph.D., P.E., F.ASCE (M)
Ronald Harichandran, Ph.D., P.E., F.ASCE (M)
David R. Martinelli, Ph.D., A.M.ASCE (M)
Robert Mimiaga, P.E., F.ASCE (M)
Craig N. Musselman, P.E., Dist.M.ASCE (M)
James K. Nelson, Ph.D., P.E., F.ASCE (M)
Ernest T. Smerdon, Ph.D., P.E., Dist.M.ASCE, NAE (M)
Daniel S. Turner, PhD., P.E., Pres.99.ASCE (M)
Stuart G. Walesh, Ph.D., P.E., D.WRE, Dist.M.ASCE (M)
Jeffrey S. Russell, Ph.D., P.E., F.ASCE (CCM)
Thomas A. Lenox, Ph.D., M.ASCE (SL)
James J. O'Brien, P.E., M.ASCE (SC)

2005-2006: CAP^3 Body of Knowledge

Richard O. Anderson, P.E., Dist.M.ASCE (C)
Kenneth J. Fridley, Ph.D., F.ASCE (VC)
Stuart G. Walesh, Ph.D., P.E., D.WRE, Dist.M.ASCE (E)
Anirban De, Ph.D., P.E., M.ASCE (M)
Decker Hains, Ph.D., P.E., M.ASCE (M)
Ronald Harichandran, Ph.D., P.E., F.ASCE (M)
Manoj K. Jha, P.E., M.ASCE (M)
William R. Knocke, Ph.D., P.E., F.ASCE (M)
David A. Lange, Ph.D., P.E., M.ASCE (M)
Melanie L. Lawrence, A.M.ASCE (M)
Timothy F. Lengyel, P.E., M.ASCE (M)
Daniel R. Lynch, Ph.D., F.ASCE (M)
Robert E. Mackey, P.E., M.ASCE (M)
John M. Mason, Ph.D., P.E., M.ASCE (M)
JoAnn Silverstein, P.E., M.ASCE (M)
Brian R. Brenner, P.E., M.ASCE (CM)
P. Champagne, Ph.D., P.E., AM.ASCE (CM)
Karen C. Chou, Ph.D., P.E., F.ASCE (CM)
Robert Ettema (CM)
Peter Hoadley, Ph.D., P.E., F.ASCE (CM)
C. Gary Kellogg, P.E., S.E., F.ASCE (CM)
Merlin Kirschenman, P.E., M.ASCE (CM)
Kenneth W. Lamb, S.M.ASCE (CM)
Jerry J. Marley, Ph.D., P.E., M.ASCE (CM)
Paul W. McMullin, P.E., M.ASCE (CM)
Donald E. Milks, Ph.D., P.E., F.ASCE (CM)
S. J. Ressler, Ph.D., P.E., Dist.M.ASCE (CM)
Steven D. Sanders, P.E., M.ASCE (CM)
Jennifer W. Shannon, P.E., M.ASCE (CM)

Alan T. Sheppard, P.E., M.ASCE (CM)
Johann F. Szautner, P.E., L.S., M.ASCE (CM)
Marlee A. Walton, P.E., M.ASCE (M)
Jeffrey S. Russell, Ph.D., P.E., F.ASCE (CCM)
Thomas A. Lenox, Ph.D., M.ASCE (SL)
James J. O'Brien, P.E., M.ASCE (SM)

2005-2006: CAP^3 Curricula

James K. Nelson, Ph.D., P.E., F.ASCE (C)
Thomas J. Siller, Ph.D., M.ASCE (VC)
Brian R. Brenner, P.E., M.ASCE (M)
Thomas J. Descoteaux, P.E., M.ASCE (M)
Allen Estes, Ph.D., P.E., M.ASCE (M)
Jeffrey C. Evans, Ph.D., P.E., M.ASCE (M)
Charles R. Glagola, Ph.D., P.E., M.ASCE (M)
Peter Hoadley, Ph.D., P.E., F.ASCE (M)
David H. Huddleston, P.E., M.ASCE (M)
Laurence J. Jacobs, Ph.D., M.ASCE (M)
Dale Jacobson, P.E., BCEE, F.ASCE (M)
Young C. Kim (M)
Robert C. Knox, A.M.ASCE (M)
Randall Kolar, P.E., A.M.ASCE (M)
David A. Lange, Ph.D., P.E., M.ASCE (M)
Debra S. Larson, P.E., M.ASCE (M)
Arthur C. Miller, Ph.D., P.E., L.S., D.WRE, F.ASCE (M)
Gayle F. Mitchell, Ph.D., P.E., M.ASCE (M)
J.P. Mohsen, Ph.D. (M)
Thomas E. Mulinazzi, Ph.D., P.E., F.ASCE (M)
Robert L. Mullen, Ph.D., P.E., F.ASCE (M)
Jay A. Puckett, Ph.D., P.E., M.ASCE (M)
Michael A. Robinson (M)
Edwin R. Schmeckpeper, P.E., M.ASCE (M)
Kevin G. Sutterer, P.E., M.ASCE (M)
Maher Tadros, Ph.D., P.E., M.ASCE (M)
John G. Tawresey, P.E., M.ASCE (M)
Stuart G. Walesh, Ph.D., P.E., D.WRE, Dist.M.ASCE (M)
Marlee A. Walton, P.E., M.ASCE (M)
Terence A. Weigel, Ph.D., P.E., M.ASCE (M)
Ronald W. Welch, Ph.D., P.E., M.ASCE (M)
Jeffrey S. Russell, Ph.D., P.E., F.ASCE (CCM)
Thomas A. Lenox, Ph.D., M.ASCE (CCM)
James J. O'Brien, P.E., M.ASCE (SL)

2005-2006: CAP^3 Licensing Committee

Craig N. Musselman, P.E., Dist.M.ASCE (C)
Dale W. Sall, P.E., L.S., F.ASCE (VC)
H. Edmund Bergeron, P.E., M.ASCE (M)
Eric L. Flicker, P.E., M.ASCE (M)
Howard C. Gibbs, P.E., M.ASCE (M)
Kerry M. Hawkins, P.E., M.ASCE (M)
E. W. LeFevre, Ph.D., P.E., Dist.M.ASCE (M)
Richard Moore (M)
Bobby E. Price, Ph.D., P.E., Dist.M.ASCE (M)
Jeffrey S. Russell, Ph.D., P.E., F.ASCE (CCM)
Thomas A. Lenox, Ph.D., M.ASCE (CSC)
Walter Marlowe, P.E., M.ASCE (SL)

2006 - 2007

2006-2007: Cmte on the Academic Prerequisites for Professional Practice (CAP^3)

Jeffrey S. Russell, Ph.D., P.E., F.ASCE (C)
Gerald E. Galloway, Ph.D., P.E., Hon.D.WRE, Dist.M.ASCE (VC)
Richard O. Anderson, P.E., Dist.M.ASCE (M)
E. W. LeFevre, Ph.D., P.E., Dist.M.ASCE (M)
Craig N. Musselman, P.E., Dist.M.ASCE (M)
Jon Nelson, P.E., M.ASCE (M)
James K. Nelson, Ph.D., P.E., F.ASCE (M)
Bobby E. Price, Ph.D., P.E., Dist.M.ASCE (M)
Stephen Ressler, Ph.D., P.E., Dist.M.ASCE (M)
James R. Schaaf, Ph.D., P.E., F.ASCE (M)
Ernest T. Smerdon, Ph.D., P.E., Dist.M.ASCE, NAE (M)
John W. Steadman, Ph.D. (M)
Stuart G. Walesh, Ph.D., P.E., D.WRE, Dist.M.ASCE (M)
Robert C. Krebs, P.E., L.S., F.ASCE (CM)
David R. Martinelli, Ph.D., A.M.ASCE (CM)
Monte L. Phillips, Ph.D., P.E., F.ASCE (CM)

Beverly W. Withiam, P.E., M.ASCE (CM)
Thomas A. Lenox, Ph.D., M.ASCE (SL)
James J. O'Brien, P.E., M.ASCE (SM)
Deborah Connor (SC)

2006-2007: CAP^3 Accreditation Committee

Stephen Ressler, Ph.D., P.E., Dist.M.ASCE (C)
Wayne R. Bergstrom, Ph.D., P.E., F.ASCE (VC)
Richard O. Anderson, P.E., Dist.M.ASCE (M)
Phillip E. Borrowman, P.E., F.ASCE (M)
Peter J. Carrato, Ph.D., P.E., F.ASCE (M)
H. Chik Erzurumlu, Ph.D., P.E., F.ASCE (M)
Ronald Harichandran, Ph.D., P.E., F.ASCE (M)
David R. Martinelli, Ph.D., A.M.ASCE (M)
Robert Mimiaga, P.E., F.ASCE (M)
Craig N. Musselman, P.E., Dist.M.ASCE (M)
James K. Nelson, Ph.D., P.E., F.ASCE (M)
Ernest T. Smerdon, Ph.D., P.E., Dist.M.ASCE, NAE (M)
Daniel S. Turner, Ph.D., P.E., Pres.99.ASCE (M)
Stuart G. Walesh, Ph.D., P.E., D.WRE, Dist.M.ASCE (M)
Beverly W. Withiam, P.E., M.ASCE (M)
Jeffrey S. Russell, Ph.D., P.E., F.ASCE (CCM)
Thomas A. Lenox, Ph.D., M.ASCE (SL)
James J. O'Brien, P.E., M.ASCE (SM)
Deborah Connor (SC)

2006-2007: CAP^3 Body of Knowledge

Richard O. Anderson, P.E., Dist.M.ASCE (C)
Kenneth J. Fridley, Ph.D., F.ASCE (VC)
Stuart G. Walesh, Ph.D., P.E., D.WRE, Dist.M.ASCE (E)
Anirban De, Ph.D., P.E., M.ASCE (M)
Decker Hains, Ph.D., P.E., M.ASCE (M)
Ronald Harichandran, Ph.D., P.E., F.ASCE (M)
Peter Hoadley, Ph.D., P.E., F.ASCE (M)
Manoj Kumar Jha, P.E., M.ASCE (M)
David A. Lange, Ph.D., P.E., M.ASCE (M)
Debra S. Larson, P.E., M.ASCE (M)
Melanie L. Lawrence, A.M.ASCE (M)
Timothy F. Lengyel, P.E., M.ASCE (M)
Daniel R. Lynch, Ph.D., F.ASCE (M)
Robert E. Mackey, P.E., M.ASCE (M)
John M. Mason, Ph.D., P.E., M.ASCE (M)
Carsten D. Ahrens, Ph.D. (CM)
A. Ang, Ph.D., S.E., NAE, Hon.M.ASCE (CM)
Tomasz Arciszewski, Ph.D., A.M.ASCE (CM)
C. R. Baillod, F.ASCE (CM)
A. Bandyopadhyay, Ph.D., P.E., F.ASCE (CM)
Brian R. Brenner, P.E., M.ASCE (CM)
Jason Burke, P.E., M.ASCE (CM)
William C. Carpenter, M.ASCE (CM)
P. Champagne, Ph.D., P.E., AM.ASCE (CM)
Karen C. Chou, Ph.D., P.E., F.ASCE (CM)
Larry A. Esvelt, Ph.D., P.E., M.ASCE (CM)
Robert Ettema, M.ASCE (CM)
Jeffrey C. Evans, Ph.D., P.E., M.ASCE (CM)
Howard C. Gibbs, P.E., M.ASCE (CM)
Ali Haghani, Ph.D., M.ASCE (CM)
Gerd W. Hartung, P.E., M.ASCE (CM)
Chris Hendrickson, Ph.D., Hon.M.ASCE (CM)
Thomas Hewett (CM)
Garabed M. Hoplamazian, P.E., M.ASCE (CM)
Kenneth C. Johns (CM)
Dinesh R. Katti, Ph.D., M.ASCE (CM)
C. Gary Kellogg, P.E., S.E., F.ASCE (CM)
William E. Kelly, P.E., F.ASCE (CM)
Merlin Kirschenman, P.E., M.ASCE (CM)
William R. Knocke, Ph.D., P.E., F.ASCE (CM)
Kenneth W. Lamb, S.M.ASCE (CM)
James L. Lee (CM)
E. W. LeFevre, Ph.D., P.E., Dist.M.ASCE (CM)
Jerry J. Marley, Ph.D., P.E., M.ASCE (CM)
Paul W. McMullin, P.E., M.ASCE (CM)
Donald E. Milks, Ph.D., P.E., F.ASCE (CM)
Adi K. Murthy (CM)
James K. Nelson, Ph.D., P.E., F.ASCE (CM)
John S. Nelson, P.E. (CM)
James K. Plemmons, P.E., M.ASCE (CM)
S. J. Ressler, Ph.D., P.E., Dist.M.ASCE (CM)
Jerry R. Rogers, Ph.D., P.E., D.WRE, Dist.M.ASCE (CM)
David I. Ruby, P.E., F.ASCE (CM)
Steven D. Sanders, P.E., M.ASCE (CM)
Subal Sarkar, P.E., M.ASCE (CM)
David M. Schwegel, P.E., A.M.ASCE (CM)
Roger K. Seals, Ph.D., P.E., F.ASCE (CM)
Jennifer W. Shannon, P.E., M.ASCE (CM)

Alan T. Sheppard, P.E., M.ASCE (CM)
Johann F. Szautner, P.E., L.S., M.ASCE (CM)
Y. Cengiz Toklu, P.E., M.ASCE (CM)
Marlee A. Walton, P.E., M.ASCE (CM)
Jeffrey S. Russell, Ph.D., P.E., F.ASCE (CCM)
Thomas A. Lenox, Ph.D., M.ASCE (SL)
James J. O'Brien, P.E., M.ASCE (SM)
Deborah Connor (SC)

2006-2007: CAP^3 Curricula

James K. Nelson, Ph.D., P.E., F.ASCE (C)
Thomas J. Siller, Ph.D., M.ASCE (VC)
Brian R. Brenner, P.E., M.ASCE (CM)
Thomas J. Descoteaux, P.E., M.ASCE (M)
Allen Estes, Ph.D., P.E., M.ASCE (M)
Jeffrey C. Evans, Ph.D., P.E., M.ASCE (M)
Charles R. Glagola, Ph.D., P.E., M.ASCE (M)
Peter Hoadley, Ph.D., P.E., F.ASCE (M)
David H. Huddleston, P.E., M.ASCE (M)
Laurence J. Jacobs, Ph.D., M.ASCE (M)
C.D. Jacobson, P.E., BCEE, F.ASCE (M)
Young C. Kim (M)
Robert C. Knox, A.M.ASCE (M)
Randall L. Kolar, P.E., M.ASCE (M)
David A. Lange, Ph.D., P.E., M.ASCE (M)
Debra S. Larson, P.E., M.ASCE (M)
Paul W. McMullin, P.E., M.ASCE (M)
Arthur C. Miller, Ph.D., P.E., L.S., D.WRE, F.ASCE (M)
Gayle F. Mitchell, Ph.D., P.E., M.ASCE (M)
J.P. Mohsen, Ph.D. (M)
Thomas E. Mulinazzi, Ph.D., P.E., F.ASCE (M)
Robert L. Mullen, Ph.D., P.E., F.ASCE (M)
Jay A. Puckett, Ph.D., P.E., M.ASCE (M)
Michael A. Robinson (M)
Edwin R. Schmeckpeper, P.E., M.ASCE (M)
Kevin G. Sutterer, P.E., M.ASCE (M)
Maher Tadros, Ph.D., P.E., M.ASCE (M)
John G. Tawresey, P.E., M.ASCE (M)
Stuart G. Walesh, Ph.D., P.E., D.WRE, Dist.M.ASCE (M)
Marlee A. Walton, P.E., M.ASCE (M)
Terence A. Weigel, Ph.D., P.E., M.ASCE (M)
Ronald W. Welch, Ph.D., P.E., M.ASCE (M)
Jeffrey S. Russell, Ph.D., P.E., F.ASCE (CCM)
Thomas A. Lenox, Ph.D., M.ASCE (CSC)
James J. O'Brien, P.E., M.ASCE (SL)
Deborah Connor (SC)

2006-2007: CAP^3 Licensing Committee

Craig N. Musselman, P.E., Dist.M.ASCE (C)
H. Edmund Bergeron, P.E., M.ASCE (M)
Eric L. Flicker, P.E., M.ASCE (M)
Howard C. Gibbs, P.E., M.ASCE (M)
Kerry M. Hawkins, P.E., M.ASCE (M)
E. W. LeFevre, Ph.D., P.E., Dist.M.ASCE (M)
Jon Nelson, P.E., M.ASCE (M)
Richard Moore (M)
Jon Nelson, P.E., M.ASCE (M)
Monte L. Phillips, Ph.D., P.E., F.ASCE (CM)
Bobby E. Price, Ph.D., P.E., Dist.M.ASCE (M)
Dale W. Sall, P.E., L.S., F.ASCE (M)
Jeffrey S. Russell, Ph.D., P.E., F.ASCE (CCM)
Thomas A. Lenox, Ph.D., M.ASCE (SL)
James J. O'Brien, P.E., M.ASCE (SM)
Deborah Connor (SC)

2007 - 2008

2007-2008: Cmte on the Academic Prerequisites for Professional Practice (CAP^3)

Jeffrey S. Russell, Ph.D., P.E., F.ASCE (C)
Gerald E. Galloway, Ph.D., P.E., Hon.D.WRE, Dist.M.ASCE (VC)
Richard O. Anderson, P.E., Dist.M.ASCE (M)
Phillip E. Borrowman, P.E., F.ASCE (M)
Kenneth J. Fridley, Ph.D., F.ASCE (M)
Manoj K. Jha, P.E., M.ASCE (M)
Craig N. Musselman, P.E., Dist.M.ASCE (M)
Jon Nelson, P.E., M.ASCE (M)
Stephen Ressler, Ph.D., P.E., Dist.M.ASCE (M)
Ernest T. Smerdon, Ph.D., P.E., Dist.M.ASCE, NAE (M)

Stuart G. Walesh, Ph.D., P.E., D.WRE, Dist.M.ASCE (M)
Robert C. Krebs, P.E., L.S., F.ASCE (CM)
E. W. LeFevre, Ph.D., P.E., Dist.M.ASCE (CM)
Monte L. Phillips, Ph.D., P.E., F.ASCE (CM)
Bobby E. Price, Ph.D., P.E., Dist.M.ASCE (CM)
Thomas A. Lenox, Ph.D., M.ASCE (SL)
James J. O'Brien, P.E., M.ASCE (SM)
Deborah Connor (SC)

2007-2008: CAP^3 Accreditation Committee

Stephen Ressler, Ph.D., P.E., Dist.M.ASCE (C)
Wayne R. Bergstrom, Ph.D., P.E., F.ASCE (VC)
Richard O. Anderson, P.E., Dist.M.ASCE (M)
Phillip E. Borrowman, P.E., F.ASCE (M)
Peter J. Carrato, Ph.D., P.E., F.ASCE (M)
H. Chik Erzurumlu, Ph.D., P.E., F.ASCE (M)
Ronald Harichandran, Ph.D., P.E., F.ASCE (M)
Robert Mimiaga, P.E., F.ASCE (M)
Ernest T. Smerdon, Ph.D., P.E., Dist.M.ASCE, NAE (M)
William L. Coulbourne, P.E., M.ASCE (CM)
Larry Feeser, Ph.D., P.E., Hon.M.ASCE (CM)
Muthusamy Krishnamurthy, Ph.D., P.E., F.ASCE (CM)
Gayle F. Mitchell, Ph.D., P.E., M.ASCE (CM)
Phillip J. Smith, P.E., M.ASCE (CM)
Beverly W. Withiam, P.E., M.ASCE (CM)
Jeffrey S. Russell, Ph.D., P.E., F.ASCE (CCM)
Thomas A. Lenox, Ph.D., M.ASCE (SL)
James J. O'Brien, P.E., M.ASCE (SM)
Deborah Connor (SC)

2007-2008: CAP^3 Body of Knowledge

Richard O. Anderson, P.E., Dist.M.ASCE (C)
Kenneth J. Fridley, Ph.D., F.ASCE (VC)
Stuart G. Walesh, Ph.D., P.E., D.WRE, Dist.M.ASCE (E)
Anirban De, Ph.D., P.E., M.ASCE (M)
Decker Hains, Ph.D., P.E., M.ASCE (M)
Ronald Harichandran, Ph.D., P.E., F.ASCE (M)
Peter Hoadley, Ph.D., P.E., F.ASCE (M)
Manoj K. Jha, P.E., M.ASCE (M)
David A. Lange, Ph.D., P.E., M.ASCE (M)
Melanie L. Lawrence, A.M.ASCE (M)
Timothy F. Lengyel, P.E., M.ASCE (M)
Robert E. Mackey, P.E., M.ASCE (M)
John M. Mason, Ph.D., P.E., M.ASCE (M)
Carsten D. Ahrens, Ph.D. (CM)
A. Ang, Ph.D., S.E., NAE, Hon.M.ASCE (CM)
Tomasz Arciszewski, Ph.D., A.M.ASCE (CM)
C. R. Baillod, F.ASCE (CM)
A. Bandyopadhyay, Ph.D., P.E., F.ASCE (CM)
Brian R. Brenner, P.E., M.ASCE (CM)
Jason Burke, P.E., M.ASCE (CM)
Donald D. Carpenter, A.M.ASCE (CM)
P. Champagne, Ph.D., P.E., AM.ASCE (CM)
Karen C. Chou, Ph.D., P.E., F.ASCE (CM)
Larry A. Esvelt, Ph.D., P.E., M.ASCE (CM)
Robert Ettema (CM)
Jeffrey C. Evans, Ph.D., P.E., M.ASCE (CM)
Howard C. Gibbs, P.E., M.ASCE (CM)
Ali Haghani, Ph.D., M.ASCE (CM)
Gerd W. Hartung, P.E., M.ASCE (CM)
Chris Hendrickson, Ph.D., Hon.M.ASCE (CM)
Thomas Hewett (CM)
Garabed M. Hoplamazian, P.E., M.ASCE (CM)
Kenneth C. Johns (CM)
Dinesh R. Katti, Ph.D., M.ASCE (CM)
C. Gary Kellogg, P.E., S.E., F.ASCE (CM)
William E. Kelly, P.E., F.ASCE (CM)
Merlin Kirschenman, P.E., M.ASCE (CM)
William R. Knocke, Ph.D., P.E., F.ASCE (CM)
Kenneth W. Lamb, S.M.ASCE (CM)
William H. Leder, P.E., F.ASCE (CM)
James L. Lee (CM)
E. W. LeFevre, Ph.D., P.E., Dist.M.ASCE (CM)
Jerry J. Marley, Ph.D., P.E., M.ASCE (CM)
Paul W. McMullin, P.E., M.ASCE (CM)
Donald E. Milks, Ph.D., P.E., F.ASCE (CM)
Adi K. Murthy (CM)
James K. Nelson, Ph.D., P.E., F.ASCE (CM)
John S. Nelson, P.E. (CM)
James K. Plemmons, P.E., M.ASCE (CM)
Stephen Ressler, Ph.D., P.E., Dist.M.ASCE (CM)

Jerry R. Rogers, Ph.D., P.E., D.WRE, Dist.M.ASCE (CM)
David I. Ruby, P.E., F.ASCE (CM)
Steven D. Sanders, P.E., M.ASCE (CM)
Subal Sarkar, P.E., M.ASCE (CM)
David M. Schwegel, P.E., A.M.ASCE (CM)
Roger K. Seals, Ph.D., P.E., F.ASCE (CM)
Jennifer W. Shannon, P.E., M.ASCE (CM)
Alan T. Sheppard, P.E., M.ASCE (CM)
Johann F. Szautner, P.E., L.S., M.ASCE (CM)
Y. Cengiz Toklu, P.E., M.ASCE (CM)
Marlee A. Walton, P.E., M.ASCE (CM)
Jeffrey S. Russell, Ph.D., P.E., F.ASCE (CCM)
Thomas A. Lenox, Ph.D., M.ASCE (SL)
James J. O'Brien, P.E., M.ASCE (SM)
Deborah Connor (SC)

2007-2008: CAP^3 Licensing Committee
Craig N. Musselman, P.E., Dist.M.ASCE (C)
H. Edmund Bergeron, P.E., M.ASCE (M)
Eric L. Flicker, P.E., M.ASCE (M)
Howard C. Gibbs, P.E., M.ASCE (M)
Kerry M. Hawkins, P.E., M.ASCE (M)
Robert C. Krebs, P.E., L.S., F.ASCE (M)
E. W. LeFevre, Ph.D., P.E., Dist.M.ASCE (CM)
Jon Nelson, P.E., M.ASCE (M)
Monte L. Phillips, Ph.D., P.E., F.ASCE (M)
Bobby E. Price, Ph.D., P.E., Dist.M.ASCE (M)
Dale W. Sall, P.E., L.S., F.ASCE (M)
Jeffrey S. Russell, Ph.D., P.E., F.ASCE (CCM)
Thomas A. Lenox, Ph.D., M.ASCE (SL)
James J. O'Brien, P.E., M.ASCE (SM)
Deborah Connor (SC)

2007-2008: CAP^3 Experience Committee
Monte L. Phillips, Ph.D., P.E., F.ASCE (C)
Forrest Holly, Ph.D., P.E. (VC)
Robert E. Mackey, P.E., M.ASCE (M)
Craig N. Musselman, P.E., Dist.M.ASCE (M)
Jeffrey S. Russell, Ph.D., P.E., F.ASCE (CCM)
Thomas A. Lenox, Ph.D., M.ASCE (SL)
James J. O'Brien, P.E., M.ASCE (SM)
Deborah Connor (SC)

2007-2008: CAP^3 BOK Educational Fulfillment Committee (BOKEdFC)
Kenneth J. Fridley, Ph.D., F.ASCE (C)
Jeffrey C. Evans, Ph.D., P.E., M.ASCE (VC)
Jeffrey S. Russell, Ph.D., P.E., F.ASCE (CCM)
Thomas A. Lenox, Ph.D., M.ASCE (SL)
James J. O'Brien, P.E., M.ASCE (SM)
Deborah Connor (SC)

2007-2008: CAP^3 BOK Experiential Fulfillment Committee (BOKExFC)
Monte L. Phillips, Ph.D., P.E., F.ASCE (C)
Forrest Holly, Ph.D., P.E. (VC)
Jeffrey S. Russell, Ph.D., P.E., F.ASCE (CCM)
Thomas A. Lenox, Ph.D., M.ASCE (SL)
James J. O'Brien, P.E., M.ASCE (SM)
Deborah Connor (SC)

2008 - 2009

2008-2009: Cmte on the Academic Prerequisites for Professional Practice (CAP^3)
Jeffrey S. Russell, Ph.D., P.E., F.ASCE (C)
Gerald E. Galloway, Ph.D., P.E., Hon.D.WRE, Dist.M.ASCE (VC)
Richard O. Anderson, P.E., Dist.M.ASCE (M)
Eugene R. Desormeaux, P.E., F.ASCE (M)
Kenneth J. Fridley, Ph.D., F.ASCE (M)
Manoj K. Jha, P.E., M.ASCE (M)
Craig N. Musselman, P.E., Dist.M.ASCE (M)
Jon Nelson, P.E., M.ASCE (M)
Kenneth Rainwater, Ph.D., P.E., M.ASCE (M)
Stephen J. Ressler, Ph.D., P.E., Dist.M.ASCE (M)

Robert A. Victor, P.E., M.ASCE (M)
Stuart G. Walesh, Ph.D., P.E., D.WRE, Dist.M.ASCE (M)
N. C. Bazan-Arias, Ph.D., P.E., M.ASCE (CM)
Phillip E. Borrowman, P.E., F.ASCE (CM)
Claudius A. Carnegie, P.E., M.ASCE (CM)
Charles R. Glagola, Ph.D., P.E., M.ASCE (CM)
C. Gary Kellogg, P.E., S.E., F.ASCE (CM)
E. W. LeFevre, Ph.D., P.E., Dist.M.ASCE (CM)
D. Lance Mearig, P.E., M.ASCE (CM)
Monte L. Phillips, Ph.D., P.E., F.ASCE (CM)
Bobby E. Price, Ph.D., P.E., Dist.M.ASCE (CM)
Ernest T. Smerdon, Ph.D., P.E., Dist.M.ASCE, NAE (CM)
Thomas A. Lenox, Ph.D., M.ASCE (SL)
James J. O'Brien, P.E., M.ASCE (SM)
Deborah Connor (SC)

2008-2009: CAP^3 Accreditation Committee

Stephen Ressler, Ph.D., P.E., Dist.M.ASCE (C)
Wayne R. Bergstrom, Ph.D., P.E., F.ASCE (VC)
Jeffrey S. Russell, Ph.D., P.E., F.ASCE (M)
Thomas A. Lenox, Ph.D., M.ASCE (SL)
James J. O'Brien, P.E., M.ASCE (SM)
Deborah Connor (SC)

2008-2009: CAP^3 Licensing Committee

Craig N. Musselman, P.E., Dist.M.ASCE (C)
Jon Nelson, P.E., M.ASCE (VC)
Robert C. Krebs, P.E., L.S., F.ASCE (M)
E. W. LeFevre, Ph.D., P.E., Dist.M.ASCE (M)
Monte L. Phillips, Ph.D., P.E., F.ASCE (M)
B. E. Price, Ph.D., P.E., Dist.M.ASCE (M)
Jeffrey S. Russell, Ph.D., P.E., F.ASCE (M)
H. Edmund Bergeron, P.E., M.ASCE (CM)
Eric L. Flicker, P.E., M.ASCE (CM)
Howard C. Gibbs, P.E., M.ASCE (CM)
Kerry M. Hawkins, P.E., M.ASCE (CM)
Forrest Holly, Ph.D., P.E. (CM)
Dale W. Sall, P.E., L.S., F.ASCE (CM)
Thomas A. Lenox, Ph.D., M.ASCE (SL)
James J. O'Brien, P.E., M.ASCE (SM)
Deborah Connor (SC)

2008-2009: CAP^3 Body of Knowledge

Richard O. Anderson, P.E., Dist.M.ASCE (C)
Kenneth J. Fridley, Ph.D., F.ASCE (VC)
Stuart G. Walesh, Ph.D., P.E., D.WRE, Dist.M.ASCE (E)
Jeffrey S. Russell, Ph.D., P.E., F.ASCE (M)
Thomas A. Lenox, Ph.D., M.ASCE (SL)
Deborah Connor (SC)

2008-2009: CAP^3 BOK Educational Fulfillment Committee

Kenneth J. Fridley, Ph.D., F.ASCE (C)
Kevin D. Hall, P.E., M.ASCE (VC)
James E. Alleman, Ph.D., P.E., M.ASCE (M)
Jean P. Bardet, Ph.D., M.ASCE (M)
Jeffrey C. Evans, Ph.D., P.E., M.ASCE (M)
Brett W. Gunnink, P.E., M.ASCE (M)
Debra S. Larson, P.E., M.ASCE (M)
George F. List, P.E., F.ASCE (M)
Kenneth L. McManis, M.ASCE (M)
Jeffrey S. Russell, Ph.D., P.E., F.ASCE (M)
Roger E. Smith, Ph.D., P.E., F.ASCE (M)
Kevin G. Sutterer, P.E., M.ASCE (M)
A. Emin Aktan, Ph.D., M.ASCE (CM)
Joan Al-Kazily, Ph.D., P.E., M.ASCE (CM)
Tomasz Arciszewski, Ph.D., A.M.ASCE (CM)
Brock E. Barry, P.E., S.M.ASCE (CM)
Brian R. Brenner, P.E., M.ASCE (CM)
William M. Bulleit, Ph.D., P.E., M.ASCE (CM)
William C. Carpenter, M.ASCE (CM)
Donald D. Carpenter, A.M.ASCE (CM)
Peter J. Carrato, Ph.D., P.E., F.ASCE (CM)
Leslie K. Daugherty, P.E., M.ASCE (CM)
Anirban De, Ph.D., P.E., M.ASCE (CM)
Michael J. Demetsky, Ph.D., P.E., F.ASCE (CM)
Charles R. Glagola, Ph.D., P.E., M.ASCE (CM)
F. E. Griggs, Ph.D., P.E., L.S., F.ASCE (CM)
Roger G. Hadgraft (CM)
Joseph P. Hanus, Ph.D., P.E., M.ASCE (CM)
Ronald Harichandran, Ph.D., P.E., F.ASCE (CM)
Harold W. Hill, P.E., M.ASCE (CM)

Merlin Kirschenman, P.E., M.ASCE (CM)
Robert C. Knox, A.M.ASCE (CM)
Robert E. Mackey, P.E., M.ASCE (CM)
Paul W. McMullin, P.E., M.ASCE (CM)
Zane W. Mitchell, M.ASCE (CM)
Philip J. Parker, A.M.ASCE (CM)
James K. Plemmons, P.E., M.ASCE (CM)
John E. Riester, P.E., M.ASCE (CM)
Jerry R. Rogers, Ph.D., P.E., D.WRE, Dist.M.ASCE (CM)
David Smith (CM)
Robert W. Stokes, Ph.D., F.ASCE (CM)
Phillip L. Thompson, P.E., M.ASCE (CM)
Dennis D. Truax, Ph.D., P.E., F.ASCE (CM)
Ronald W. Welch, Ph.D., P.E., M.ASCE (CM)
Scott A. Yost, P.E., M.ASCE (CM)
Thomas A. Lenox, Ph.D., M.ASCE (SL)
James J. O'Brien, P.E., M.ASCE (SM)
Deborah Connor (SC)

2008-2009: CAP^3 BOK Experiential Fulfillment Committee

Monte L. Phillips, Ph.D., P.E., F.ASCE (C)
Forrest Holly, Ph.D., P.E. (VC)
Wayne R. Bergstrom, Ph.D., P.E., F.ASCE (M)
Daniel E. Campbell, P.E., S.E., M.ASCE (M)
John L. Carrato, P.E., F.ASCE (M)
Margie M. De Laurell, P.E., M.ASCE (M)
Kurt D. Fischer, A.M.ASCE (M)
Robert C. Krebs, P.E., L.S., F.ASCE (M)
Robert E. Mackey, P.E., M.ASCE (M)
Jeffrey S. Russell, Ph.D., P.E., F.ASCE (M)
Franklin Sherkow, P.E., M.ASCE (M)
William A. Straub (M)
Glen R. Andersen, A.M.ASCE (CM)
G. E. Brandow, Ph.D., P.E., S.E., M.ASCE (CM)
David L. Dahl, P.E., M.ASCE (CM)
William W. Edgerton, P.E., M.ASCE (CM)
Walter W. Farrell, P.E., F.ASCE (CM)
Alfred K. Gand, A.M.ASCE (CM)
Mahmoud M.S. Khoncarly (CM)
Michael G. Lewis (CM)
Paul W. McMullin, P.E., M.ASCE (CM)
Craig N. Musselman, P.E., Dist.M.ASCE (CM)
Kenneth L. Roley, P.E., M.ASCE (CM)
Steven D. Sanders, P.E., M.ASCE (CM)
Berrin Tansel, Ph.D., P.E., F.ASCE (CM)
Michael H. Wenning, P.E., M.ASCE (CM)
John J. Winzler, A.M.ASCE (CM)
Thomas A. Lenox, Ph.D., M.ASCE (SL)
James J. O'Brien, P.E., M.ASCE (SM)
Deborah Connor (SC)

2008-2009: ASCE Plus 30 Task Force Committee

G. Nicholas Textor, P.E., D.WRE, F.ASCE (C)
Joseph M. Cibor, P.E., M.ASCE (M)
Gerald E. Galloway, Ph.D., P.E., D.WRE, Dist.M.ASCE (M)
John Jaeger, Ph.D., P.E., M.ASCE (M)
Sandra L. Houston, Ph.D., P.E., M.ASCE (M)
Soheila Rahbari, P.E., M.ASCE (M)
Jim Rowings, Ph.D., P.E., F.ASCE (M)
Roger Smith, Ph.D., P.E., M.ASCE (M)
Paul Taylor, P.E., M.ASCE (M)
Larry Roth, P.E., G.E., F.ASCE (SC)

2009 - 2010

2009-2010: Cmte on the Academic Prerequisites for Professional Practice (CAP^3)

Jeffrey S. Russell, Ph.D., P.E., Dist.M.ASCE (C)
Gerald E. Galloway Jr., Ph.D., P.E. (VC)
Richard O. Anderson, P.E., Dist.M.ASCE (M)
Joseph M. Cibor, P.E., Hon.D.GE, M.ASCE (M)
Kenneth J. Fridley, Ph.D., F.ASCE (M)
Dale Jacobson, P.E., F.ASCE (M)
Craig N. Musselman, P.E., Dist.M.ASCE (M)
Jon Nelson, P.E., Dist.M.ASCE (M)
Kenneth Rainwater, Ph.D., P.E., M.ASCE (M)
Stephen J. Ressler, Ph.D., P.E., M.ASCE (M)

Robert A. Victor, P.E., M.ASCE (M)
Stuart G. Walesh, Ph.D., P.E., D.WRE, Dist.M.ASCE (M)
N. C. Bazan-Arias, Ph.D., P.E., M.ASCE (CM)
Phillip E. Borrowman, P.E., F.ASCE (CM)
Claudius A. Carnegie, P.E., M.ASCE (CM)
Charles R. Glagola, Ph.D., P.E., M.ASCE (CM)
C. Gary Kellogg, P.E., S.E., F.ASCE (CM)
D. Lance Mearig, P.E., M.ASCE (CM)
James J. O'Brien, Jr., P.E., M.ASCE (CM)
Monte L. Phillips, Ph.D., P.E., F.ASCE (CM)
Bobby E. Price, Ph.D., P.E., Dist.M.ASCE (CM)
Thomas A. Lenox, Ph.D., M.ASCE (SL)
Deborah Connor (SC)

2009-2010: CAP^3 Accreditation Committee
Stephen J. Ressler, Ph.D., P.E., M.ASCE (C)
Wayne R. Bergstrom, Ph.D., P.E., F.ASCE (VC)
Jeffrey Russell, Ph.D., P.E., Dist.M.ASCE (M)
Thomas A. Lenox, Ph.D., M.ASCE (SL)
James J. O'Brien, Jr., P.E., M.ASCE (SM)
Deborah Connor (SC)

2009-2010: CAP^3 Licensing Committee
Craig N. Musselman, P.E., Dist.M.ASCE (C)
Jon Nelson, P.E., Dist.M.ASCE (VC)
Kenneth J. Fridley, Ph.D., F.ASCE (M)
Roger M. Helgoth (M)
Robert C. Krebs, P.E., L.S., F.ASCE (M)
James K. Nelson, Jr., Ph.D., P.E., F.ASCE (M)
Monte L. Phillips, Ph.D., P.E., F.ASCE (M)
Jeffrey Russell, Ph.D., P.E., Dist.M.ASCE (M)
G. Nicholas Textor, P.E., D.WRE, F.ASCE (M)
H. Edmund Bergeron, P.E., M.ASCE (CM)
Eric L. Flicker, P.E., M.ASCE (CM)
Howard C. Gibbs, P.E., M.ASCE (CM)
Kerry M. Hawkins, P.E., M.ASCE (CM)
Forrest Holly, Ph.D., P.E. (CM)
Norma J. Mattei, P.E., M.ASCE (CM)
James J. O'Brien, Jr., P.E., M.ASCE (CM)
Dale W. Sall, P.E., L.S., F. (CM)
Thomas A. Lenox, Ph.D., M.ASCE (SL)
Deborah Connor (SC)

2009-2010: CAP^3 Advocacy Committee
Gerald E. Galloway Jr., Ph.D., P.E., Dist.M.ASCE (C)
Jeffrey S. Russell, Ph.D., P.E., F.ASCE (VC)
Robert A. Victor, P.E., M.ASCE (M)
Stuart G. Walesh, Ph.D., P.E., D.WRE, Dist.M.ASCE (M)
Thomas A. Lenox, Ph.D., M.ASCE (SL)
Deborah Connor (SC)

2009-2010: CAP^3 Body of Knowledge
Richard O. Anderson, P.E., Dist.M.ASCE (C)
Kenneth J. Fridley, Ph.D., F.ASCE (VC)
Stuart G. Walesh, Ph.D., P.E., D.WRE, Dist.M.ASCE (E)
Jeffrey S. Russell, Ph.D., P.E., F.ASCE (M)
Thomas A. Lenox, Ph.D., M.ASCE (SL)
Deborah Connor (SC)

2009-2010: CAP^3 BOK Educational Fulfillment Committee
Kenneth J. Fridley, Ph.D., F.ASCE (C)
Kevin D. Hall, Ph.D., P.E., M.ASCE (VC)
James E. Alleman, Ph.D., P.E., M.ASCE (M)
Jean P. Bardet, Ph.D., M.ASCE (M)
Brett W. Gunnink, P.E., M.ASCE (M)
Debra S. Larson, P.E., M.ASCE (M)
George F. List, P.E., F.ASCE (M)
Kenneth McManis, Ph.D., P.E., M.ASCE (M)
Jeffrey Russell, Ph.D., P.E., Dist.M.ASCE (M)
Roger E. Smith, Ph.D., P.E., F.ASCE (M)
Kevin G. Sutterer, P.E., M.ASCE (M)
A. Emin Aktan, Ph.D., M.ASCE (CM)
Joan Al-Kazily, Ph.D., P.E., M.ASCE (CM)
Tomasz Arciszewski, Ph.D., A.M.ASCE (CM)
Brock E. Barry, P.E., M.ASCE (CM)
Brian R. Brenner, P.E., F.ASCE (CM)

William M. Bulleit, Ph.D., P.E., M.ASCE (CM)
Donald D. Carpenter, A.M.ASCE (CM)
William C. Carpenter, M.ASCE (CM)
Peter J. Carrato, Ph.D., P.E., F.ASCE (CM)
Leslie K. Daugherty, P.E., M.ASCE (CM)
Anirban De, Ph.D., P.E., M.ASCE (CM)
Michael J. Demetsky, Ph.D., P.E., F.ASCE (CM)
Jeffrey C. Evans, Ph.D., P.E., M.ASCE (CM)
Charles R. Glagola, Ph.D., P.E., M.ASCE (CM)
Francis Griggs, Ph.D., P.E., L.S., F.ASCE (CM)
Roger G. Hadgraft (CM)
Joseph P. Hanus, Ph.D., P.E., M.ASCE (CM)
Ronald Harichandran, Ph.D., P.E., F.ASCE (CM)
Harold W. Hill, P.E., M.ASCE (CM)
Merlin Kirschenman, P.E., M.ASCE (CM)
Robert C. Knox, A.M.ASCE (CM)
Robert E. Mackey, P.E., F.ASCE (CM)
Paul W. McMullin, P.E., M.ASCE (CM)
Zane W. Mitchell, Jr., M.ASCE (CM)
James J. O'Brien, Jr., P.E., M.ASCE (CM)
Philip J. Parker, A.M.ASCE (CM)
James K. Plemmons, P.E., M.ASCE (CM)
John E. Riester, Jr., P.E., M.ASCE (CM)
Jerry R. Rogers, Ph.D., P.E., D.WRE, Dist.M.ASCE (CM)
David Smith (CM)
Robert W. Stokes, Ph.D., F.ASCE (CM)
Phillip L. Thompson, P.E., M.ASCE (CM)
Dennis D. Truax, Ph.D., P.E., F.ASCE (CM)
Ronald W. Welch, Ph.D., P.E., M.ASCE (CM)
Scott A. Yost, P.E., M.ASCE (CM)
Thomas A. Lenox, Ph.D., M.ASCE (SL)
Deborah Connor (SC)

2009-2010: CAP^3 BOK Experiential Fulfillment Committee

Monte Leroy Phillips, Ph.D., P.E., F.ASCE (C)
Forrest Holly, Ph.D., P.E. (VC)
Wayne R. Bergstrom, Ph.D., P.E., F.ASCE (M)
Daniel E. Campbell, P.E., S.E., M.ASCE (M)
John L. Carrato, P.E., F.ASCE (M)
Margie M. De Laurell, P.E., M.ASCE (M)
Kurt D. Fischer, A.M.ASCE (M)
Robert C. Krebs, P.E., L.S., F.ASCE (M)
Robert E. Mackey, P.E., M.ASCE (M)
Jeffrey S. Russell, Ph.D., P.E., F.ASCE (M)
Franklin Sherkow, P.E., M.ASCE (M)
William A. Straub, P.E., M.ASCE (M)
Glen R. Andersen, A.M.ASCE (CM)
G. Brandow, Ph.D., P.E., S.E., M.ASCE (CM)
David L. Dahl, P.E., M.ASCE (CM)
William W. Edgerton, P.E., M.ASCE (CM)
Walter W. Farrell, P.E., F.ASCE (CM)
Alfred Kofi Gand, A.M.ASCE (CM)
Mahmoud M.S. Khoncarly (CM)
Michael G. Lewis, P.E., M.ASCE (CM)
Paul W. McMullin, P.E., M.ASCE (CM)
Craig N. Musselman, P.E., Dist.M.ASCE (CM)
James J. O'Brien, P.E., M.ASCE (CM)
Kenneth L. Roley, P.E., M.ASCE (CM)
Steven D. Sanders, P.E., M.ASCE (CM)
Berrin Tansel, Ph.D., P.E., F.ASCE (CM)
Michael H. Wenning, P.E., M.ASCE (CM)
John J. Winzler, A.M.ASCE (CM)
Thomas A. Lenox, Ph.D., M.ASCE (SL)
Deborah Connor (SC)

2009-2010: Task Committee on Implementing the Competency Strategy (TCICS)

Thomas M. Rachford, Ph.D., P.E., F.ASCE (C)
Christine F. Andersen, P.E., M.ASCE (M)
Jennifer B. Epp, P.E., M.ASCE (M)
Gerald E. Galloway, Jr., Ph.D., P.E., Hon.D.WRE, Dist.M.ASCE (M)
D. Wayne Klotz, P.E., D.WRE, F.ASCE (M)
Edward L. Robinson, P.E., L.S., F.ASCE (M)
Robert A. Victor, P.E., M.ASCE (M)
Nicholas Textor, P.E., D.WRE, F.ASCE (CM)
Charles (Casey) Dinges, Aff.M.ASCE (SC) :
Jeff Russell, Ph.D., P.E., Dist.M.ASCE (EOM)

2010 - 2011

2010-2011: Cmte on the Academic Prerequisites for Professional Practice (CAP3)

Jeffrey S. Russell, Ph.D., P.E., Dist.M.ASCE (C)
Gerald E. Galloway Jr., Ph.D., P.E., Dist.M.ASCE (VC)
Joseph M. Cibor, P.E., D.GE, M.ASCE (M)
Kenneth J. Fridley, Ph.D., F.ASCE (M)
Dale Jacobson, P.E., F.ASCE (M)
Craig N. Musselman, P.E., Dist.M.ASCE (M)
Jon Nelson, P.E., Dist.M.ASCE (M)
William J. Rahmeyer, M.ASCE (M)
Kenneth Rainwater, Ph.D., P.E., M.ASCE (M)
Stephen Ressler, P.E., Ph.D., Dist.M.ASCE (M)
Robert A. Victor, P.E., M.ASCE (M)
Stuart G. Walesh, Ph.D., P.E., D.WRE, Dist.M.ASCE (M)
Richard Anderson (CM)
N. C. Bazan-Arias, Ph.D., P.E., F.ASCE (CM)
Wayne R. Bergstrom, Ph.D., P.E., F.ASCE (CM)
Phillip E. Borrowman, P.E., F.ASCE (CM)
Claudius A. Carnegie, P.E., M.ASCE (CM)
Eugene R. Desormeaux, P.E., F.ASCE (CM)
Charles R. Glagola, Ph.D., P.E., M.ASCE (CM)
C Gary Kellogg, P.E., S.E., F.ASCE (CM)
Robert C. Krebs, P.E., L.S., F.ASCE (CM)
Sanjeev Kumar, Ph.D., P.E., F.ASCE (CM)
D. Lance Mearig, P.E., M.ASCE (CM)
David G. Mongan, P.E., Pres.08.ASCE (CM)
James K. Nelson Jr., Ph.D., P.E., F.ASCE (CM)
James J. O'Brien Jr., P.E., M.ASCE (CM)
Monte L. Phillips, Ph.D., P.E., F.ASCE (CM)
Bobby E. Price, Ph.D., P.E., Dist.M.ASCE (CM)
E. T. Smerdon, Ph.D., P.E., Dist.M.ASCE (CM)
Thomas A. Lenox, Ph.D., M.ASCE (SL)
Deborah Connor (SC)

2010-2011: CAP^3 Accreditation Committee

Stephen Ressler, Ph.D., P.E., Dist.M.ASCE (C)
Wayne Bergstrom, Ph.D., P.E., F.ASCE (VC)
Jeffrey S. Russell, Ph.D., P.E., F.ASCE (M)
Thomas A. Lenox, Ph.D., M.ASCE (SL)
James J. O'Brien, P.E., M.ASCE (SM)
Deborah Connor (SC)

2010-2011: CAP^3 Licensing Committee

Craig N. Musselman, P.E., Dist.M.ASCE (C)
Jon Nelson, P.E., Dist.M.ASCE (VC)
Kenneth J. Fridley, Ph.D., F.ASCE (M)
Roger M. Helgoth (M)
Robert C. Krebs, P.E., L.S., F.ASCE (M)
James K. Nelson Jr., Ph.D., P.E., F.ASCE (M)
Monte L. Phillips, Ph.D., P.E., F.ASCE (M)
Jeffrey Russell, Ph.D., P.E., Dist.M.ASCE (M)
Eric L. Flicker, P.E., M.ASCE (CM)
Howard C. Gibbs, P.E., M.ASCE (CM)
Kerry M. Hawkins, P.E., M.ASCE (CM)
Forrest Holly, Ph.D., P.E. (CM)
Norma J. Mattei, Ph.D., P.E., M.ASCE (CM)
James J. O'Brien Jr., P.E., M.ASCE (CM)
Dale W. Sall, P.E., L.S., F.ASCE (CM)
G. Nicholas Textor, P.E., D.WRE, F.ASCE (CM)
Thomas A. Lenox, Ph.D., M.ASCE (SL)
Deborah Connor (SC)

2010-2011: CAP^3 Advocacy Committee

Jeffrey S. Russell, Ph.D., P.E., Dist.M.ASCE (C)
Kenneth J. Fridley, Ph.D., F.ASCE (M)
Dale Jacobson, P.E., F.ASCE (M)
Jon Nelson, P.E., Dist.M.ASCE (M)
Stuart G. Walesh, Ph.D., P.E., D.WRE, Dist.M.ASCE (M)
Nancy E. Berson, Aff.M.ASCE (M)
Joan Buhrman (M)
Adam Gagnon (M)
Jane Howell (M)
James J. O'Brien Jr., P.E., M.ASCE (M)
Brian T. Pallasch, Aff.M.ASCE (M)
Thomas A. Lenox, Ph.D., M.ASCE (SL)
Deborah Connor (SC)

2010-2011: CAP^3 Body of Knowledge

Richard O. Anderson, P.E., Dist.M.ASCE (C)
Kenneth J. Fridley, Ph.D., F.ASCE (VC)
Stuart G. Walesh, Ph.D., P.E., D.WRE, Dist.M.ASCE (E)
Jeffrey Russell, Ph.D., P.E., Dist.M.ASCE (M)
Thomas A. Lenox, Ph.D., M.ASCE (SL)
Deborah Connor (ASCE Staff)

2010-2011: CAP^3 BOK Educational Fulfillment Committee

Kenneth J. Fridley, Ph.D., F.ASCE (C)
Kevin D. Hall, Ph.D., P.E., M.ASCE (VC)
James E. Alleman, Ph.D., P.E., M.ASCE (M)
Jean P. Bardet, Ph.D., M.ASCE (M)
Brett W. Gunnink, P.E., M.ASCE (M)
Debra S. Larson, P.E., M.ASCE (M)
George F. List, P.E., F.ASCE (M)
Kenneth L. McManis, Ph.D., P.E., M.ASCE (M)
Jeffrey Russell, Ph.D., P.E., Dist.M.ASCE (M)
Roger E. Smith, Ph.D., P.E., F.ASCE (M)
Kevin G. Sutterer, P.E., M.ASCE (M)
A Emin Aktan, Ph.D., M.ASCE (CM)
Joan Al-Kazily, Ph.D., P.E., M.ASCE (CM)
Tomasz Arciszewski, Ph.D., A.M.ASCE (CM)
Brock E. Barry, P.E., M.ASCE (CM)
Brian R. Brenner, P.E., F.ASCE (CM)
William M. Bulleit, Ph.D., P.E., M.ASCE (CM)
Donald D. Carpenter, P.E., M.ASCE (CM)
William C. Carpenter, M.ASCE (CM)
Peter J. Carrato, Ph.D., P.E., F.ASCE (CM)
Leslie K. Daugherty, P.E., M.ASCE (CM)
Anirban De, Ph.D., P.E., M.ASCE (CM)
Michael J. Demetsky, Ph.D., P.E., F.ASCE (CM)
Jeffrey C. Evans, Ph.D., P.E., M.ASCE (CM)
Charles R. Glagola, Ph.D., P.E., M.ASCE (CM)
Francis Griggs Jr., Ph.D., P.E., L.S., F.ASCE (CM)
Roger G. Hadgraft (CM)
Joseph P. Hanus, Ph.D., P.E., M.ASCE (CM)
Ronald Harichandran, Ph.D., P.E., F.ASCE (CM)
Harold W. Hill, P.E., M.ASCE (CM)
Merlin Kirschenman, P.E., M.ASCE (CM)
Robert C. Knox, A.M.ASCE (CM)
Robert E. Mackey, P.E., F.ASCE (CM)
Paul W. McMullin, P.E., M.ASCE (CM)
Zane W. Mitchell Jr., M.ASCE (CM)
James J. O'Brien Jr., P.E., M.ASCE (CM)
Philip J. Parker, A.M.ASCE (CM)
James K. Plemmons, P.E., M.ASCE (CM)
John E. Riester Jr., P.E., M.ASCE (CM)
Jerry R. Rogers, Ph.D., P.E., D.WRE, Dist.M.ASCE (CM)
David Smith, (CM)
Robert W. Stokes, Ph.D., F.ASCE (CM)
Phillip L. Thompson, P.E., M.ASCE (CM)
Dennis D. Truax, Ph.D., P.E., F.ASCE (CM)
Ronald W. Welch, Ph.D., P.E., M.ASCE (CM)
Scott A. Yost, P.E., M.ASCE (CM)
Thomas A. Lenox, Ph.D., M.ASCE (SL)
Deborah Connor (SC)

2010-2011: CAP^3 BOK Experiential Fulfillment Committee

Monte L. Phillips, Ph.D., P.E., F.ASCE (C)
Forrest Holly, Ph.D., P.E. (VC)
Wayne Bergstrom, Ph.D., P.E., F.ASCE (M)
Daniel Campbell, P.E., S.E., M.ASCE (M)
John L. Carrato, P.E., F.ASCE (M)
Margie M. De Laurell, P.E., M.ASCE (M)
Kurt D. Fischer, A.M.ASCE (M)
Robert C. Krebs, P.E., L.S., F.ASCE (M)
Robert E. Mackey, P.E., F.ASCE (M)
Jeffrey Russell, Ph.D., P.E., Dist.M.ASCE (M)
Franklin Sherkow, P.E., F.ASCE (M)
William A. Straub, P.E., M.ASCE (M)
Glen R. Andersen, A.M.ASCE (CM)
G. Brandow, Ph.D., P.E., S.E., M.ASCE (CM)
David L. Dahl, P.E., M.ASCE (CM)
William W. Edgerton, P.E., M.ASCE (CM)
Walter W. Farrell, P.E., F.ASCE (CM)
Alfred K. Gand, A.M.ASCE (CM)
Mahmoud Khoncarly, Ph.D., P.E., M.ASCE (CM)
Michael G. Lewis, P.E., M.ASCE (CM)
Paul W. McMullin, P.E., M.ASCE (CM)
Craig Musselman, P.E., Dist.M.ASCE (CM)
James J. O'Brien Jr., P.E., M.ASCE (CM)
Kenneth L. Roley, P.E., M.ASCE (CM)

Steven D. Sanders, P.E., M.ASCE (CM)
Berrin Tansel, Ph.D., P.E., F.ASCE (CM)
Michael H. Wenning, P.E., F.ASCE (CM)
John J. Winzler, A.M.ASCE (CM)
Thomas A. Lenox, Ph.D., M.ASCE (SL)
Deborah Connor (SC)

2010-2011: CAP^3 Accreditation Policy Committee

Stephen Ressler, P.E., Ph.D., Dist.M.ASCE (C)
Wayne R. Bergstrom, Ph.D., P.E., F.ASCE (VC)
Amitabha M. Bandyopadhyay, Ph.D., P.E., F.ASCE (M)
David Binning, P.E., M.ASCE (M)
Larry J. Feeser, Ph.D., P.E., Dist.M.ASCE (M)
William H. Highter, P.E., Ph.D., F.ASCE (M)
Jeffrey Russell, Ph.D., P.E., Dist.M.ASCE (M)
Thomas A. Lenox, Ph.D., M.ASCE (SL)
James J. O'Brien Jr., P.E., M.ASCE (SM)
Dion K. Coward (SM)
Deborah Connor (SC)

2010-2011: Task Committee on Implementing the Competency Strategy – 2 (TCICS2)

Blaine Leonard, P.E., F.ASCE (C)
Jennifer B. Epp, P.E., M.ASCE (M)
Gerald E. Galloway, Jr., Ph.D., P.E., Hon.D.WRE, Dist.M.ASCE (M)
Eric L Flicker, P.E., L.S., M.ASCE (M)
Robert A. Victor, P.E., M.ASCE
Mark W. Woodson, P.E., L.S., F.ASCE (M)
Bradley F. Aldrich, P.E., F.ASCE (CM)
Jeffrey S. Russell, Ph.D., P.E., Dist.M.ASCE (CM)
Stefan Jaeger, CAE (SL)

2011 - 2012

2011-2012: Cmte on the Academic Prerequisites for Professional Practice (CAP^3)

Jeffrey S. Russell, Ph.D., P.E., Dist.M.ASCE (C)
Gerald E. Galloway Jr., Ph.D., P.E., Dist.M.ASCE (VC)
Joseph M. Cibor, P.E., D.GE, M.ASCE (M)
Kenneth J. Fridley, Ph.D., F.ASCE (M)
Dale Jacobson, P.E., F.ASCE (M)
Craig N. Musselman, P.E., Dist.M.ASCE (M)
Jon Nelson, P.E., Dist.M.ASCE (M)
William J. Rahmeyer, M.ASCE (M)
Kenneth Rainwater, Ph.D., P.E., M.ASCE (M)
Stephen Ressler, P.E., Ph.D., Dist.M.ASCE (M)
Robert A. Victor, P.E., M.ASCE (M)
Stuart G. Walesh, Ph.D., P.E., D.WRE, Dist.M.ASCE (M)
Richard O. Anderson, P.E., Dist.M.ASCE (CM)
Wayne R. Bergstrom, Ph.D., P.E., F.ASCE (CM)
Phillip E. Borrowman, P.E., F.ASCE (CM)
Claudius Carnegie, P.E., P.Eng, M.ASCE (CM)
Eugene R. Desormeaux, P.E., F.ASCE (CM)
Robert C. Krebs, P.E., L.S., F.ASCE (CM)
Sanjeev Kumar, Ph.D., P.E., F.ASCE (CM)
D. Lance Mearig, P.E., M.ASCE (CM)
David Mongan, P.E., Pres.08.ASCE (CM)
James Nelson, Ph.D., P.E., F.ASCE (CM)
James J. O'Brien Jr., P.E., M.ASCE (CM)
Monte Phillips, Ph.D., P.E., F.ASCE (CM)
B. E. Price, Ph.D., P.E., Dist.M.ASCE (CM)
E. T. Smerdon, Ph.D., P.E., Dist.M.ASCE (CM)
Thomas A. Lenox, Ph.D., M.ASCE (SL)
Deborah Connor (SC)

2011-2012: CAP^3 Accreditation Policy Committee

Stephen Ressler, P.E., Ph.D., Dist.M.ASCE (C)
Wayne R. Bergstrom, Ph.D., P.E., F.ASCE (VC)
Amitabha M. Bandyopadhyay, Ph.D., P.E., F.ASCE (M)
David Binning, P.E., M.ASCE (M)
Larry J. Feeser, Ph.D., P.E., Dist.M.ASCE (M)
William H. Highter, P.E., Ph.D., F.ASCE (M)
Jeffrey Russell, Ph.D., P.E., Dist.M.ASCE (M)
Thomas A. Lenox, Ph.D., M.ASCE (SL)
James J. O'Brien Jr., P.E., M.ASCE (SM)
Dion K. Coward (SM)
Deborah Connor (SC)

2011-2012: CAP^3 Licensing Committee

Craig N. Musselman, P.E., Dist.M.ASCE (C)
Jon Nelson, P.E., M.ASCE (VC)
Kenneth J. Fridley, Ph.D., F.ASCE (M)
Roger M. Helgoth (M)
Robert C. Krebs, P.E., L.S., F.ASCE (M)
Monte L. Phillips, Ph.D., P.E., F.ASCE (M)
Jeffrey S. Russell, Ph.D., P.E., F.ASCE (M)
Eric L. Flicker, P.E., L.S., M.ASCE (CM)
Howard C. Gibbs, P.E., M.ASCE (CM)
Forrest Holly, Ph.D., P.E. (CM)
Sanjeev Kumar, Ph.D., P.E., F.ASCE (CM)
Norma J. Mattei, Ph.D., P.E., M.ASCE (CM)
Dale W. Sall, P.E., L.S., F.ASCE (CM)
Thomas A. Lenox, Ph.D., M.ASCE (SL)
James J. O'Brien Jr., P.E., M.ASCE (SM)
Deborah Connor (SC)

2011-2012: CAP^3 Body of Knowledge

Richard O. Anderson, P.E., Dist.M.ASCE (C)
Kenneth J. Fridley, Ph.D., F.ASCE (VC)
Stuart G. Walesh, Ph.D., P.E., D.WRE, Dist.M.ASCE (E)
Jeffrey S. Russell, Ph.D., P.E., F.ASCE (CCM)
Thomas A. Lenox, Ph.D., M.ASCE (SL)
Deborah Connor (SC)

2011-2012: CAP^3 BOK Educational Fulfillment Committee

Kenneth J. Fridley, Ph.D., F.ASCE (C)
Kevin D. Hall, P.E., M.ASCE (VC)
Jeffrey S. Russell, Ph.D., P.E., F.ASCE (CCM)
Thomas A. Lenox, Ph.D., M.ASCE (SL)
Deborah Connor (SC)

2011-2012: CAP^3 BOK Experiential Fulfillment Committee

Monte L. Phillips, Ph.D., P.E., F.ASCE (C)
Forrest Holly, Ph.D., P.E. (VC)
Jeffrey S. Russell, Ph.D., P.E., F.ASCE (CCM)
Thomas A. Lenox, Ph.D., M.ASCE (SL)

2011-2012: Task Committee on Implementing the Competency Strategy Two (TCICS2)

Blaine Leonard, P.E., F.ASCE (C)
Jennifer B. Epp, P.E., M.ASCE (M)
Gerald E. Galloway, Jr., Ph.D., P.E., Hon.D.WRE, Dist.M.ASCE (M)
Eric L Flicker, P.E., L.S., M.ASCE (M)
Robert A. Victor, P.E., M.ASCE (M)
Mark W. Woodson, P.E., L.S., F.ASCE (M)
Bradley F. Aldrich, P.E., F.ASCE (CM)
Jeffrey Russell, Ph.D., P.E., Dist.M.ASCE (CM)
Stefan Jaeger, CAE (SL)

Appendix D

ASCE Presidents Supporting and Leading the Raise the Bar Initiative 1998 - 2012

The authors also wish to express their gratitude to the leaders of the American Society of Civil Engineers for their unfailing support of the Raise the Bar initiative, the Committee on the Academic Prerequisites for Professional Practice (CAP^3), and the CAP^3 leaders since 1998. The continuity of their support, vision, and leadership was critical to the furthering of the Raise the Bar initiative.

ASCE Past Presidents

1997-1998:	Luther W. Graef, P.E., Pres.98.ASCE
1998-1999:	Daniel S. Turner, Ph.D., P.E., Pres.99.ASCE
1999-2000:	Delon Hampton, Ph.D., P.E., Pres.00.ASCE
2000-2001:	Robert W. Bein, P.E., Pres.01.ASCE
2001-2002:	H. Gerard Schwartz, Jr., P.E., Pres.02.ASCE
2002-2003:	Thomas L. Jackson, P.E., Pres.03.ASCE
2003-2004:	Patricia D. Galloway, Ph.D., P.E., Pres.04.ASCE
2004-2005:	William P. Henry, P.E., Pres.05.ASCE
2005-2006:	Dennis R. Martenson, P.E., Pres.06.ASCE
2006-2007:	William F. Marcuson III, Ph.D., P.E., Pres.07.ASCE
2007-2008:	David G. Mongan, P.E., Pres.08.ASCE
2008-2009:	D. Wayne Klotz, P.E., Pres.09.ASCE
2009-2010:	Blaine D. Leonard, P.E., Pres.10.ASCE
2010-2011:	Kathy J. Caldwell, P.E., Pres.11.ASCE
2011-2012:	Andrew W. Herrmann, P.E., Pres.12.ASCE
2012-2013:	Greg DiLoreto, P.E., Pres.13.ASCE

This page intentionally left blank

Chapter 2

Sociology of Professions: Application to the Civil Engineering "Raise the Bar" Initiative

Stephen J. Ressler, P.E., Ph.D., Dist.M.ASCE, *U.S. Military Academy*

Sociology of Professions: Application to the Civil Engineering "Raise the Bar" Initiative

Stephen J. Ressler, P.E., Dist.M.ASCE[1]

Abstract: This paper applies the sociological theory of professions, as espoused by Abbott and Freidson, as a conceptual framework to assess the critical issues associated with the ongoing implementation of ASCE Policy Statement 465—also called the "Raise the Bar" initiative. The sociology of professions provides an objective basis for evaluating key aspects of the initiative, including publication of the civil engineering body of knowledge, raising educational standards for licensure, collaboration with other engineering disciplines, and defining the role of paraprofessionals. The analysis demonstrates the following: (1) the models of professionalism by Abbott and Freidson are highly applicable to civil engineering; (2) most aspects of Policy Statement 465 implementation are consistent with these models; (3) the initiative is contributing to the strength of the profession as intended; and (4) some future additions and adjustments appear to be warranted. From this analysis, the author derives recommendations for the future direction of the Raise the Bar initiative. **DOI: 10.1061/(ASCE)EI.1943-5541.0000043.**

CE Database subject headings: Professional role; Professional societies; Professional personnel; Engineering education; Professional practice; Licensing.

Author keywords: Professions; Professional role; Professional societies; Professional personnel; Engineering education; Professional practice; Licensure.

Background

For over a decade, ASCE has been engaged in an ambitious effort to better prepare civil engineering professionals to meet the technological, environmental, economic, social, and political challenges of the future. This "Raise the Bar" initiative attained an important milestone in October 1998, when the ASCE Board of Direction formally adopted Policy Statement 465. The most recent version of this policy is as follows:

> The ASCE supports the attainment of a body of knowledge for entry into the practice of civil engineering at the professional level. This would be accomplished through the adoption of appropriate engineering education and experience requirements as a prerequisite for licensure (ASCE 2007).

In conjunction with the implementation of Policy 465, ASCE initiated a comprehensive effort to formally define the profession's body of knowledge (BOK). The *Civil Engineering Body of Knowledge for the 21st Century* (ASCE 2004) was first published in January 2004. In response to feedback from across the profession, a revised edition (ASCE 2008) was released four years later. The BOK is defined in terms of 24 outcomes, which address five broad curricular areas:

- Fundamentals in math and natural science;
- Breadth in the humanities and social sciences;
- Technical breadth;
- Professional practice breadth; and
- Technical depth or specialization.

In contrast to traditional civil engineering curricula, as reflected in the accreditation criteria [Engineering Accreditation Commission (EAC) 2003] that were in effect when the original BOK was formulated, the most recent edition of the BOK places increased emphasis on the natural sciences, humanities, problem recognition, history and heritage, sustainability, risk and uncertainty, project management, public policy, business, public administration, globalization, leadership, and attitudes. A recently implemented change to the Accreditation Board for Engineering and Technology (ABET) civil engineering program criteria incorporates some, but not all, of these topics (EAC 2008).

As the BOK has been developed and refined, a concurrent analysis has demonstrated that the BOK outcomes cannot be adequately achieved through the traditional four-year baccalaureate degree. Consequently, Policy 465 specifies that the BOK should be fulfilled through (1) a baccalaureate degree in civil engineering; (2) a master's degree or approximately 30 graduate or upper-level undergraduate credits; and (3) appropriate progressive, structured engineering experience.

ASCE is currently attempting to influence state laws to reflect the increased educational requirement for licensure. In 2006, with ASCE's strong support, the National Council of Examiners for Engineering and Surveying (NCEES) modified its model law requirements for engineering licensure (NCEES 2006). The revised model law states that admission to the engineering licensing exam will require a bachelor's degree and an additional 30 credits of acceptable upper-level undergraduate or graduate-level coursework from approved course providers. In 2008, the effective date for the new model law was set at January 2020.

Although the implementation of Policy 465 has made steady and substantial progress since 1998, the process has often been contentious. Various aspects of the initiative have been opposed by individual educators and practitioners, the Engineering Deans

[1]Professor and Head, Dept. of Civil and Mechanical Engineering, U.S. Military Academy, West Point, NY 10996. E-mail: stephen.ressler@usma.edu

Note. This manuscript was submitted on November 25, 2009; approved on July 8, 2010; published online on June 15, 2011. Discussion period open until December 1, 2011; separate discussions must be submitted for individual papers. This paper is part of the ***Journal of Professional Issues in Engineering Education & Practice***, Vol. 137, No. 3, July 1, 2011. ©ASCE, ISSN 1052-3928/2011/3-151–161/$25.00.

Council (ASEE 2006), the American Council of Engineering Companies (ACEC 2008), and professional societies affiliated with other engineering disciplines (Holt 2009). These disagreements have concerned a wide range of issues, including the nature and severity of the problem, the need for additional education, quality versus quantity of engineers, accreditation, the importance of licensure, the relationships among the engineering disciplines, and the respective roles of educators, practitioners, and paraprofessionals. In response, proponents have sought to legitimize the Raise the Bar initiative by citing various strategic vision documents [National Academy of Engineering (NAE) 2004, 2005] and empirical data, e.g., reduced credit hour requirements in civil engineering programs and increased educational requirements in other professions. Opponents have also occasionally cited empirical data, e.g., the lack of any significant decline in Fundamentals of Engineering Exam pass rates. In general, however, most participants in the debate have relied primarily on anecdotal evidence, personal experience, and speculation about the future consequences of the initiative (NCEES 2009). Thus far, neither advocates nor opponents have sought to assess the validity of Policy 465 in the context of a broader theoretical framework. Yet just such a framework exists in an extensive body of scholarship called the sociology of professions.

Purpose and Scope

The purpose of the paper is to apply the sociological theory of professions to assess the implementation of ASCE's Policy Statement 465. The research question is as follows: is Policy Statement 465 being implemented in a manner that will tend to strengthen the civil engineering profession? To establish a basis for this analysis, the historical development of the sociology of professions is summarized, and the theoretical models proposed by Abbott and Freidson are identified as being particularly applicable to civil engineering. Critical issues associated with Policy 465 are then analyzed in the context of these models. Consistencies and inconsistencies are identified, and concomitant recommendations for the future direction of the Raise the Bar initiative are proposed.

Sociology of Professions

Although modern professions are thought to have their origins in the medieval guilds, the formal academic study of professionalism did not begin until the 1930s. Many early sociological studies attempted to identify the essential traits of "true professions" and then to examine various real-world occupations with respect to these traits (Carr-Saunders and Wilson 1933). This approach eventually fell out of favor because the subjectivity inherent in defining essential traits often resulted in inconsistent conclusions. Thus, for example, "If one disliked social work, one easily found some trait excluding social work from the prestigious category of 'professions'" (Abbott 1988, p. 4).

Through the middle years of the twentieth century, the study of professions was heavily influenced by *functionalism*, the dominant theoretical framework of modern sociology. Functionalists have attempted to define the role that the professions play in the established order of society (MacDonald 1995). For example, the functionalist perspective can be seen in the concept of "asymmetry of expertise"—the idea that the professional's specialized expertise requires the client to trust the professional, and the professional is ethically obligated to serve the client's best interest (Lawson 2004). Although much of the literature on professions reflects a functionalist orientation, some recent theorists have described this approach as fundamentally limited because it is focused primarily on what professions are, rather than how they develop and maintain their special position in the marketplace (MacDonald 1995).

An alternative approach is seen in another midtwentieth century development—the theory of *professionalization*. This theory suggests that all real-world professions are developing along a path toward an ideal end state. Advocates of professionalization favor its focus on development over time, rather than static traits, and its utility in explaining the inherent variability in the empirical characteristics of real-world professions. More recently, in response to the changing political climate of the 1960s, Larson (1977) examined professionalization in terms of the professions' tendency to acquire monopolistic control over both markets and social status. The theory of professionalization also has its critics, who cite its inability to account for the interactions between professions and the loss of professional status occasionally experienced by real-world occupations (Abbott 1988, p. 18).

In 1988, Andrew Abbott revolutionized the sociology of professions with his publication of *The System of Professions*. Abbott's approach is unique in that he applies systems analysis concepts to characterize the professions as interdependent elements of a complex, dynamic system. At the heart of Abbott's model is the concept of *jurisdiction*—the link between a profession and its work. Each profession claims a jurisdiction on the basis of its associated body of expert knowledge. Control of a jurisdiction generally entails the right to perform work as the profession sees fit, to exclude others from doing the same work, and to publicly define the tasks being performed.

Within Abbott's system of professions, a *disturbance* is created when one occupation attempts to claim another's jurisdiction, or when external forces (such as technological change) create new jurisdictions or destroy existing jurisdictions. The disturbance then propagates through the system as a succession of jurisdictional contests between occupations. Eventually the disturbance is absorbed, either by professionalization of a nonprofessional occupation, by deprofessionalization of a professional group, or by internal changes within a profession. Ultimately the outcomes of these jurisdictional disputes determine whether professions prosper, combine, divide, stratify, or fail. Because professional tasks are constantly changing, new jurisdictional disputes are always arising. Consequently, there can be no long-term equilibrium in the system.

In *Professionalism: The Third Logic*, Eliot Freidson (2001) draws heavily upon both Abbott and Larson but adopts a fundamentally different approach. Rather than describing the historical development of professions or characterizing them at a particular place and time, Freidson develops the *logic of professionalism* as one of three paradigms for the division of labor in an economic system. These three paradigms are as follows:

- The *free market*, first articulated by Adam Smith in *The Wealth of Nations*, is a labor market in which the division of labor is determined by consumers. An ideal-typical free market is characterized by free entry and exit, complete knowledge of the marketplace, a sufficient number of buyers and sellers, and the absence of collusion. Workers in an ideal free market have little need for specialized training; they acquire working knowledge on the job. They move freely from one job to the next, based on available wage rates, and their work is seldom recognized as belonging to distinct occupations.
- The *bureaucracy*, as defined by Max Weber, is an entity in which the division of labor is determined by an organizational hierarchy (Weber 1947). The ideal-typical bureaucracy is characterized by a systematic organization with jobs defined by

written rules specifying function and position in the organizational hierarchy. In an ideal-typical bureaucracy, hiring is based on impersonal criteria and personnel policies, and wages are based on position and seniority. Workers' ultimate responsibility is to a supervisor, rather than to consumers of the organization's products and services.
- The *profession*, Freidson's "third logic," is an occupation in which the division of labor is determined by the members of the occupation itself. The essential characteristic of an ideal-typical profession is the ability of its members to control their own work through the discretionary application of specialized knowledge.

More specifically, the third logic—the ideal-typical profession—is defined in terms of five interdependent elements (Freidson 2001, p. 127) as follows:
- Specialized work, grounded in an officially recognized body of knowledge that is based on abstract concepts and requires the exercise of discretion;
- Exclusive jurisdiction in a division of labor created and controlled by the occupation;
- A sheltered position in the labor market based on qualifying credentials created by the occupation;
- A formal training program that lies outside the labor market, produces the credential, is controlled by the occupation, and is associated with higher education; and
- An ideology that serves one or more transcendent values and claims greater commitment to doing good work than to economic reward.

It is important to recognize that all three of Freidson's paradigms—free market, bureaucracy, and profession—are theoretical ideal types. As defined in the *Encyclopedia Britannica*, an ideal type is an analytical construct that is "derived from observable reality although not conforming to it in detail because of deliberate simplification and exaggeration." An ideal type captures the essential distinguishing characteristics of a phenomenon without attempting to reflect all of the specific characteristics of empirical examples.

Thus the strength of Freidson's ideal-typical model is that its formulation relies primarily on logic. It provides a stable, rationally derived conceptual framework that can effectively organize our view of professionalism, independent of highly variable real-world circumstances.

Although Abbott and Freidson address professionalism generally and theoretically, they also provide numerous examples and case studies illustrating the historical development and current status of many modern professions, including engineering. Other scholars have applied aspects of the sociology of professions to more narrowly focused analyses of the medical profession (Epstein and Hundert 2002), the military profession (Snider and Watkins 2002), the engineering profession (Krause 1999), and the civil engineering specifically (Lawson 2004). Yet, despite its broad acceptance and rich content, the sociology of professions has not yet been applied rigorously to ASCE's Raise the Bar initiative.

Application to ASCE Policy Statement 465

Taken together, the theories of Abbott and Freidson provide a powerful framework for evaluating the strength of a given real-world profession. According to Abbott, the strength of a profession is manifested in its ability to maintain exclusive control over its jurisdiction. The sources of that strength are reflected in the five elements of Freidson's ideal-typical model. Thus the strength of a real-world profession can be measured by the extent to which its characteristics reflect those of the ideal-typical model.

As such, Freidson's model also provides an effective basis for evaluating the implementation of Policy 465. Any aspect of this initiative that tends to move the civil engineering profession closer to Freidson's ideal-typical model can be regarded as a strengthening influence; any aspect that contradicts the model is likely to weaken the profession. In the following sections, this approach is applied to an analysis of the civil engineering profession in general and critical issues associated with Policy 465 in particular.

Although this analysis derives principally from the work of Abbott and Freidson, their theories are not claimed to be universally accepted and other valid perspectives on professionalism do exist. Nonetheless, Abbott and Freidson are appropriately authoritative sources, as reflected in the frequent citations of their work in the literature; moreover, as this analysis will demonstrate, their theories are particularly applicable to civil engineering and thus are particularly well suited to the purpose of this paper.

Body of Knowledge

Formalizing the Professional Body of Knowledge

In both Abbott's and Freidson's theoretical models, a body of specialized knowledge is central to professionalism. A profession's BOK is the principal basis for its jurisdictional claims compared with other occupations. Using historical examples, Abbott (1988, p. 56) demonstrates that jurisdictional claims are generally strengthened when a profession defines the boundaries of its jurisdiction more clearly. Thus, ASCE's decision to formally define and publish the civil engineering BOK can be expected to strengthen the profession by clearly and publicly delineating its jurisdictional claims. This conclusion is supported by the fact that, in the years since ASCE first published its BOK, at least three other engineering societies have initiated projects to do the same (AAEE 2008; Johnson 2009; Laity 2004).

There are potential risks in formally defining a BOK, however. The system of professions is inherently dynamic, with contested jurisdictions constantly in flux. A profession that formally defines its BOK may hinder its ability to adapt its jurisdictional boundaries in response to emerging threats or opportunities. ASCE has mitigated this risk in two ways—first, by defining its BOK in terms of outcomes, rather than specific content; and, second, by committing to regular updates of the published BOK (ASCE 2008).

Consider the case of *sustainability*, an emerging area of intense interest over which engineers, scientists, architects, public policy professionals, and a variety of other occupations have claimed some jurisdiction. The first edition of ASCE's published BOK did not include sustainability as a stand-alone outcome, but the second edition did—a clear use of the published BOK to strengthen a jurisdictional claim. Of course, merely claiming a jurisdiction does not guarantee that the claimant will actually be able to control the associated professional work. The outcomes of jurisdictional contests are determined, more often than not, by the efficacy of the "treatments" offered by the contesting professions (Abbott 1988, p. 100). It remains to be seen whether civil engineers will be able to develop treatments that are more effective at solving sustainability problems than the solutions offered by other occupations.

Abstraction and Discretionary Judgment in the BOK

The most important characteristic of a professional BOK is the nature of the expert knowledge contained therein. According to

Freidson, the BOK of an ideal-typical profession must be based on abstract concepts or theories, and the application of these theories must entail the exercise of discretionary judgment. Professional work

> requires extensive exercise of discretionary judgment rather than the choice and routine application of a limited number of mechanical techniques. Hence it is more important to have a firm grounding in basic theory and concepts to guide discretionary judgment than to gain practice in what can only be a selection from among all the concrete practical and working knowledge that particular work settings require (Freidson 2001, p. 95).

When a BOK is strongly grounded in abstract knowledge, the associated profession has a considerable advantage in jurisdictional contests. For example, in the 1960s, much of the exploding demand for electrical engineers in the United States was met by physicists, rather than engineers. The physicists' highly theoretical educational background enabled them to master new applications at least as easily as did the graduates of engineering schools (Abbott 1988, p. 181).

Conversely, lack of abstraction can weaken a profession and leave it vulnerable to attack or obsolescence. Abbott suggests that the professional railroad dispatchers of the early twentieth century might have evolved into today's systems engineers if their BOK had been sufficiently generalizable. In practice, however, their expert knowledge was too closely tied to the practical task of managing railroads; so when the railroads vanished, the dispatchers vanished along with them (Abbott 1988, p. 93).

The application of discretionary judgment is also critical to professionalism. If a profession's BOK can be codified or automated—that is, if decisions regarding the disciplinary domain can be made without the exercise of discretion—the professional's role is greatly diminished, and the profession is correspondingly weakened. Engineering is inherently susceptible to this tendency because "the body of engineering knowledge is so exact that it is constantly in danger of obsolescence through mechanization or advances in knowledge and technique, and its workers are susceptible to displacement by workers with lesser training" (Freidson 2001, p. 169). Krause (1999, p. 33) also emphasizes that engineers' expert knowledge is particularly vulnerable to new technological developments.

Given the importance of abstraction, the civil engineering BOK's enhanced emphasis on theoretical subjects—mathematics, natural science, and engineering science—is a positive change. The requirement for enhanced technical depth, attained through graduate-level study, is also laudable because it reflects a trend toward a higher level of specialized knowledge. Moreover, the BOK's emphasis on risk and uncertainty represents an appropriate counter to the notion that engineering knowledge is too exact.

Another salient feature of the formally defined civil engineering BOK is enhanced professional practice breadth, reflected in outcomes associated with such topics as communication skills, public policy, business, public administration, globalization, and teamwork. Freidson's model suggests that because these outcomes are not specific to the civil engineering discipline, they will not directly contribute to the profession's ability to defend its core jurisdiction. In a broader sense, however, there is considerable evidence that such knowledge and skills will significantly enhance engineers' ability to exercise discretionary judgment by providing a broader, more holistic context for decision-making (Augustine 2009; Grasso 2008). Therefore, inclusion of professional practice outcomes in the civil engineering BOK is appropriate, as long as these subjects do not displace critical math, science, or engineering content. Raising the academic prerequisite for licensure will alleviate this constraint considerably by shifting technical depth to the graduate level while opening up space for professional practice topics in the baccalaureate curriculum.

Humanities in the BOK

An ideal professional education is generally accompanied by "book learning in the academic or liberal studies of the ideas, theories, and works treasured by the cultivated elite" (Freidson 2001, p. 96). Most professions claim that the liberal arts provide an intellectual foundation for learning the professional BOK. Freidson suggests that these studies are at least as important for preserving the social status desired by professionals. Regardless, the humanities and social sciences are included as foundational outcomes in the civil engineering BOK, and this emphasis is consistent with the model of ideal-typical professionalism.

Professional Labor Market Shelter and Licensure

The most fundamental characteristic of professionalism, control of work by the occupation itself, requires the establishment of a *labor market shelter*—a monopoly over the specialized work performed by members of the profession (Freidson 2001, p. 78). Ideally, the monopoly is sanctioned by law: the state mandates that only qualified professionals can perform specified types of work. The mechanism for this mandate is a *credential*—typically a professional license that is created and granted by the profession.

The purposes of the labor market shelter are to protect the profession from external competition with other occupations, to protect it from internal competition between members of the profession, and to alleviate financial encumbrances that might adversely affect professionals' ability to serve their clients effectively. The state provides protection from external competition by granting the profession exclusive permission to perform certain types of specialized work. The profession controls internal competition through restraints on competitive bidding and advertising. Ideally, the profession also restricts its supply of practitioners by setting rigorous standards for admission into professional schools and for attainment of the credential.

Because they deliberately limit competition, professional labor market shelters are often viewed negatively by consumers. Yet they are absolutely essential for the viability of professionalism; therefore, they ultimately benefit society by ensuring that professionals' specialized knowledge is available in the marketplace.

In engineering, the labor market shelter is institutionalized through laws requiring professional licensure for certain kinds of engineering work. Licensure is, by definition, exclusionary: granting one profession the right to use a professional title and to do specified work excludes all others from doing the same. The state also privileges licensed professionals by applying the malpractice standard, rather than the strict liability standard, to their work (Jacobson 2009). For these reasons, licensure laws tend to strengthen the segment of the engineering profession to which they apply.

In this context, the existence of an *industrial exemption*, by which engineers working in manufacturing industries are permitted to practice without licensure, is highly damaging to the strength of the profession. When engineers practice under an industrial exemption, the employing company assumes liability for their work (Timms 2009). Thus the engineers effectively surrender control of their work to an organizational hierarchy. The result is a labor market that corresponds more closely to Freidson's "second logic"—the bureaucracy—than to professionalism.

Viewed from this perspective, ASCE's continued emphasis on professional licensure—in Policy 465 itself, in the published BOK, and in ongoing efforts to influence state licensure laws—is both exemplary and essential. Raising the educational standard for engineering licensure will further strengthen the labor market shelter and strengthen the portion of the profession to which the standard applies. Yet the lack of a "monopoly licensure system," applicable to all engineers, will continue to fundamentally compromise the strength of the profession (Krause 1999, p. 62).

Professionalism versus Bureaucracy in the Engineering Disciplines

As the preceding discussion suggests, there is an inherent tension between professionalism and bureaucracy. A recent example can be seen in the medical profession, in which large hospitals, health maintenance organizations, and other bureaucratic structures have been created to control costs by limiting physicians' discretionary control over their own work.

Engineering is regarded as an inherently weak profession because of the corporate setting in which engineering work is typically performed (Krause 1999, p. 35). Because the process of translating engineering designs into physical products requires large amounts of capital, engineers are often dependent on large privately owned organizations (Abbott 1988, p. 156). In such organizations, engineering typically represents just one specialty in a much larger division of labor. Consequently, engineers, unlike lawyers and accountants, cannot control the market for their services and generally have not been able to dominate the organizations in which they work (Krause 1999, p. 61). Freidson cites one notable exception to this rule, however.

> Today, there are a few powerful and wealthy engineering corporations that are analogous to the autonomous professional organizations of large law and accounting firms, but by and large such independent practice in industrial nations is rare *for all but civil engineers* [emphasis added] (Freidson 2001, p. 168).

Although Freidson provides no direct explanation for the exceptional nature of civil engineering, reasons can be seen in the nature of civil engineering work and its relationship to the professional labor market shelter. In comparison with the work other engineering disciplines perform, civil engineering products are more likely to require the seal of a licensed professional. This is the case because the products of civil engineering typically are created and remain within a single legal jurisdiction. Conversely, manufactured products are usually sold outside of the states in which they are made; thus, federal protection of interstate commerce prevents state regulation of this form of engineering work. [For an example of a licensure exemption based on interstate commerce, see New York State Education Department (2009) Article 145, §7208.j.] Consequently, a significantly greater proportion of civil engineers seek professional licensure (Fig. 1), and a correspondingly smaller proportion practice under an industrial exemption.

Two other inherent characteristics of civil engineering work tend to strengthen the profession in comparison with other engineering disciplines. First, the U.S. construction industry segregates the professional functions of planning and design from the more craft-oriented functions of fabrication and construction. In manufacturing industries, design and production are more integrated—an arrangement that, no doubt, enhances quality and efficiency, but also blurs the distinction between professional and nonprofessional work.

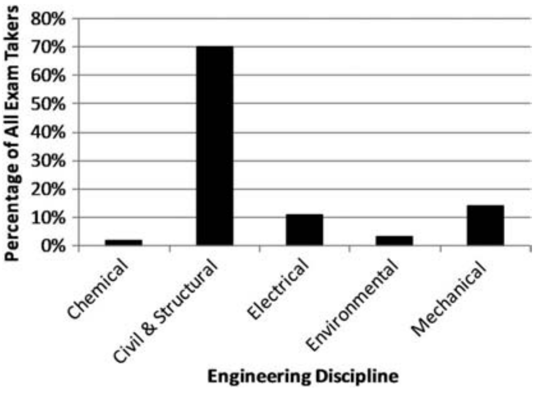


Fig. 1. Percentage of PE exam takers by engineering discipline for the past five years (data from T. Miller, NCEES director of examination services, personal communication, 2009)

Second, civil engineers typically create large-scale one-of-a-kind systems that must be designed correctly on the first attempt. Unlike engineers in manufacturing industries, civil engineers cannot build and test physical prototypes before handing off their designs for production. In theory, a profession that gets only one chance to solve a problem tends to be stronger than a profession that is allowed multiple attempts (Abbott 1988, p. 49). The latter is more vulnerable because it will inevitably experience more "treatment failures," and these are often the basis for jurisdictional attacks or loss of professional status.

Abbott and Freidson assert that the engineering profession is inherently weak because of its organizational context; nonetheless, the preceding observations demonstrate that individual engineering disciplines vary widely in this respect. Freidson himself acknowledges that civil engineering is different. Given the broad spectrum of real-world possibilities ranging from the ideal-typical profession (reflecting pure occupational control of work) to the ideal-typical bureaucracy (reflecting organizational control of work), civil engineering is demonstrably closer to the ideal-typical profession than engineering disciplines that are more heavily engaged in manufacturing.

It is hardly surprising, then, that professional societies representing other engineering disciplines have opposed ASCE's Raise the Bar initiative. Manufacturing-oriented disciplines are closely controlled by the commercial industries they serve (Krause 1999, p. 67). Historically, these industries have opposed engineers' efforts to professionalize to preserve flexibility and obtain technical skills at the lowest possible cost (Freidson 2001, p. 170). According to Abbott (1988, p. 154), corporations typically hire at the baccalaureate level to save money and then provide in-house training as a means of building their employees' loyalty to the firm, rather than to the profession, and to better protect proprietary information.

Deborah Grubbe reinforces this point powerfully, if unintentionally, in a recent opinion piece (Grubbe 2009). A petroleum industry executive, Grubbe opposes ASCE's Raise the Bar initiative on the grounds that increased educational requirements for engineers would be irrelevant to "wealth-generating businesses," such as the petrochemical, aerospace, automotive, and electronics industries. Because these industries transform raw materials into salable products, she says, they generate more "raw wealth" than the service industries that employ civil engineers. Therefore, "wealth-generating businesses" have more money to spend on the in-house training of their engineers. These firms "have no need for B + 30 [a baccalaureate degree plus 30 additional credits] when a B.S. will do just fine" (Grubbe 2009). This argument clearly reinforces Abbott's point about corporate hiring practices, yet it fails to account for the fact that the "B + 30" standard applies to licensure, but engineers working in "wealth-generating businesses" practice under an industrial exemption and seldom seek licensure.

Significantly, industry groups and professional societies associated with manufacturing-oriented engineering disciplines have been most vocal in warning that raising standards for licensure will cause shortages of engineers. In practice, claims of an impending engineer shortage have been disputed (Teitelbaum 2007); and, in any event, the law of supply and demand suggests that any shortage of engineers could be addressed by raising salaries. Thus industries' warnings of engineer shortages can reasonably be interpreted as attempts to preserve the availability of low-cost engineering services. As noted previously, strong professions typically seek to restrict the number of practitioners by setting rigorous standards for attainment of the professional credential. In contrast, efforts to increase the number of engineering practitioners by resisting higher licensing standards clearly reflect the best interests of industry and not of the engineering profession.

For these reasons, it may be unrealistic for ASCE to expect cooperation from all but closely related disciplines in implementing Policy 465. In general, the engineering disciplines' ability to act in concert with one another is limited by "fragmentation into a variety of virtually unrelated specialties practicing in so many industrial sectors that few common interests link its members" (Freidson 2001, p. 170). It has even been suggested that engineering should not be considered a single profession at all. "Engineering, despite the single name given to practitioners, in fact competes largely by specialty—civil, mechanical, and so on—and should really be treated as several professions" (Abbott 1988, p. 82). In Abbott's systems model, the separate engineering professions are as likely to be competitors as collaborators.

This is not to say that ASCE is destined to go it alone. The American Academy of Environmental Engineers, the National Society for Professional Engineers, and the National Council of Examiners for Engineering and Surveying are natural allies. Many educators and practitioners in other engineering disciplines support the initiative, even in cases in which their professional societies do not. More importantly, historical examples suggest that, when one occupational group raises its professional standards, competing professions often feel compelled to respond by raising their standards as well (Abbott 1988, p. 97). If ASCE leads, there is good reason to anticipate that others will follow.

Role of the University

A key aspect of professionalism is its connection to the university—a connection that distinguishes professionals from craftsmen, who are typically trained on the job. Like training in the craft occupations, professional education is controlled and conducted by members of the profession. Unlike the crafts, professional education is generally provided by full-time teachers who are not expected to work in the labor market (Freidson 2001, p. 92).

In engineering, professional control over education is exerted primarily through accreditation by the EAC of ABET. As ABET member societies, professional engineering organizations contribute to the formulation of accreditation criteria and provide volunteers to serve as program evaluators. Accreditation connects to professional licensure through state requirements for an EAC-accredited degree as one of the prerequisites for qualification as an engineering intern and, subsequently, as a professional engineer. Given these connections, ASCE's effort to enhance educational fulfillment of the BOK through modifications to the EAC criteria is an appropriate mechanism for strengthening the profession.

In Freidson's ideal-typical model, university programs

- Prepare students to attain the professional credential;
- Formalize the BOK by incorporating it into the curriculum;
- Provide the educational basis for jurisdictional claims in relation to other professions;
- Refine and expand the BOK through research;
- Serve as the primary source of the profession's status and public identity;
- Contribute to students' commitment to the profession as a career; and
- Contribute to a shared identity among members of the profession.

Of all these purposes, both Abbott and Freidson place particular emphasis on the importance of research. Expanding the BOK through research is seen as an essential means of defending and expanding the profession's jurisdiction. There is a well-documented tendency for professional knowledge to become commodified over time (Abbott 1988, p. 146). For example, in civil engineering, classical methods of structural analysis have been largely absorbed into modern computer software tools. Commodification always results in a corresponding loss of professional work. Research is vital for replacing these losses with new knowledge and skills.

In the civil engineering community, research is sometimes portrayed as being independent of, or even contrary to, the Policy 465 initiative. The published civil engineering BOK says relatively little about research. However, the sociology of professions suggests that research should be fully incorporated into the initiative as a driver for ensuring the long-term vitality of the BOK.

The ideal-typical model also emphasizes the critical role that education plays in developing students' professional identities and values. This role is reflected in ASCE's strong support of student activities and in the inclusion of an outcome relating to attitudes in the civil engineering BOK.

Tension between Educators and Practitioners

Tension between educators and practitioners has been evident in many of the deliberations associated with the Raise the Bar initiative. Some practitioners have claimed that educators are out of touch with the needs of the profession, that engineering curricula do not provide graduates with the practical skills required for practice, and that educators focus too heavily on research. Gordon (2007), a prominent practitioner, writes that "engineering education must get real" and that "those who can, do, and those who can't, teach." Educators respond that many practical skills are best learned through experience, that practitioners must do more to impart these skills, and that forcing educational institutions to teach professional practice topics only dilutes the quality of a technical education. Krause (1999, p. 61) suggests that excessive corporate influence over engineering curricula is weakening the profession. The tone of these discussions might lead one to believe that these issues are unique to engineering. In reality, sociologists tell us that such tensions between educators and practitioners are intrinsic to professionalism.

In all professions, the importance of abstract theory in the BOK is often contested by practitioners, "who chafe under the authority claimed by theorists who do not have to dirty their hands with reality" (Freidson 2001, pp. 153–154). Yet, as we have seen, the abstract character of the BOK is critical to the strength of a profession.

Furthermore, "practitioners are likely to resent the intellectual authority of the faculty," in part because of the faculty's insulation from the everyday compromises and improvisations required of practitioners working in a world of incomplete information and finite resources (Freidson 2001, p. 100). This resentment notwithstanding, the relatively insulated position of the faculty outside of the labor market is essential for professionalism because it allows educators to focus on systematizing, refining, and expanding the BOK over which the profession claims jurisdiction. This focus provides the profession with the capacity to innovate and adapt in response to technological change and society's increasing expectations. As portions of the BOK become obsolete over time, the faculty must be equipped to expand the jurisdiction into new areas to ensure the profession's long-term viability.

Although faculty in all disciplines tend to resent the imposition of "soft skills" and professional practice topics in the curriculum, these subjects can provide context for enhanced discretionary decision making and need not detract from the technical content of a professional education, as discussed previously.

It appears, then, that tension between educators and practitioners often arises from claims that are largely without merit. Although we may lessen this tension through better communication, we must also accept it as a fundamental aspect of the professional landscape.

Differentiation within the Profession

Although Abbott's system of professions is concerned primarily with interactions between professions, jurisdictional disputes can occur within a profession as well. The continual expansion of knowledge and the invention of new skills often results in differentiation within a professional jurisdiction. The most common form of differentiation is termed *division of labor*. It occurs when segments of a professional BOK gradually become defined as specialties, and the associated specialists attempt to gain exclusive control over the specialty jurisdiction. Such specialty jurisdictions may remain within the parent profession (they often develop special education requirements and certification programs), or they may break away to form new professions. For example, in the nineteenth century, most architects did their own engineering. But as the process of designing buildings became more complex, it was necessary for the architects to effect a division of labor with civil engineers (Abbott 1988, p. 73). In 1952, sanitary engineers associated with ASCE's Committee for the Advancement of Sanitary Engineering initiated a process that ultimately resulted in the establishment of an independent professional society, the American Academy of Environmental Engineers in 1967 (AAEE 2009). Today this same trend can be seen in the establishment of ASCE's eight technical specialty institutes (ASCE 2009).

Because of this natural tendency toward division, a mature profession generally cannot be regarded as a single community of interest. Rather, it is a highly differentiated collection of subcommunities, which may hold contradictory policy positions. Thus, the ability of a professional society to effect strategic reform across an entire profession is highly constrained. For example, in recent years, the National Council of Structural Engineers Associations (NCSEA) has advocated a specialized baccalaureate-level curriculum in structural engineering (NCSEA 2006) even as ASCE has promoted technical specialization at the master's level.

Freidson suggests that such conflicts are inevitable and that conflicting policy positions must be considered legitimate, as long as they are based on professional criteria. Thus, ASCE must continue to accommodate conflicting viewpoints within the community and advance its agenda through persuasion and collaboration.

Another way that internal jurisdictional disputes can be resolved within a profession is by client differentiation, with professionals assuming responsibility for elite clients and nonprofessionals servicing lower-level clients or customers (Abbott 1988, p. 77). This trend is evident in the U.S. construction industry today. Civil engineers typically lead the design of heavy construction projects, but they are subordinate to architects in commercial building design and have been largely replaced by nonprofessional builders in residential construction. Abbott warns that the legitimacy of a profession will be compromised if the general public becomes aware of client differentiation. Because the general public is well aware of engineers' noninvolvement in residential construction, this form of client differentiation could be a contributor to civil engineers' lack of public prestige.

Role and Status of Paraprofessionals

As discussed previously, the ideal-typical profession establishes demanding standards for education and credentialing to ensure high standards of performance, limit the supply of practitioners, and preserve its labor market shelter. Restricting entry can be problematic, however, in times of increased demand on the profession or reduced supply of practitioners. Under these circumstances, the profession may be unable to meet its workload and, consequently, its jurisdiction may be vulnerable to claims by other occupational groups. To guard against this vulnerability, professions typically create subordinate groups that are capable of handling "dangerously routine" professional work (Abbott 1988, p. 72). These subordinate groups are generally called *paraprofessionals*. In civil engineering, paraprofessionals are further differentiated as *technologists*, who are typically graduates of four-year Technology Accreditation Commission (TAC)–accredited degree programs, and *technicians*, who are graduates of education or training programs no more than two years in duration [ASCE Paraprofessional Exploratory Task Committee (PETC) 2008].

It is evident that paraprofessionals, and technologists in particular, will be critical to the successful implementation of ASCE Policy 465. As the academic prerequisite for licensure is increased, the supply of licensed professionals can reasonably be expected to decrease, at least initially. A smaller number of better-educated professionals will necessarily be engaged in the profession's most demanding work—tasks requiring a high degree of discretionary judgment. But the remaining work, more routine and less rigorous, will need to be accomplished by increased numbers of well-qualified technologists.

Their important function notwithstanding, paraprofessionals' position in the labor force tends to be both ambiguous and unstable (Freidson 2001, p. 90). Some paraprofessionals, such as nurses, exercise considerable control over their work, but most are subordinate to professionals or lay managers. Some require a credential; others do not. Over time, some may advance to professional status; indeed, paraprofessionals often seek to blur the distinction between professionals and paraprofessionals as a way to facilitate upward mobility (Abbott 1988, p. 66). But many other paraprofessionals are made obsolete by new technologies or are downgraded to the status of semiskilled workers. This tendency toward obsolescence results primarily from the relative lack of abstraction in the paraprofessionals' BOK, and it causes the paraprofessionals' position in the work force to be inherently vulnerable, no matter how valuable their current work may be.

Given this vulnerability, it is not surprising that members of the civil engineering technology community have expressed concern with the implementation of Policy 465. In particular, some U.S.

states currently permit graduates of four-year engineering technology programs to attain professional registration, and there is significant concern that the Raise the Bar initiative may constrain this path to licensure in the future. There is also a broader concern that the technology community's role in the initiative has not been fully defined and that its interests have not been adequately addressed.

In 2008, ASCE responded to these concerns by forming the PETC. The committee made substantial progress toward clarifying the roles of civil engineering technologists and technicians. In its final report, the PETC also recommended (1) credentialing for engineering paraprofessionals; (2) better recognition and communication of paraprofessionals' contributions; and (3) better opportunities for paraprofessionals to participate in professional societies (ASCE PETC 2008). As a follow-up to these recommendations, ASCE has formed a new Paraprofessional Task Committee, which is developing recommendations to improve the utilization, recognition, and support of civil engineering paraprofessionals.

In the context of the sociology of professions, ASCE's ongoing efforts to define a distinct, valued, and clearly subordinate role for technologists is well founded. As Abbott (1988, p. 72) suggests, failure to institutionalize the subordination of paraprofessionals publicly and legally can increase a profession's vulnerability. Thus, providing paths for civil engineering technologists to attain professional licensure could weaken the profession unless provisions are made to ensure that the full professional BOK is attained before the credential is awarded. Technologists who attain professional licensure are no longer paraprofessionals—they are professionals and thus should meet professional standards. From this perspective, the PETC's recommendation for paraprofessional credentialing is particularly valuable. An appropriate credential would provide recognition, distinct from licensure, to which technologists could aspire; this recognition would be based on educational and experiential qualifications that technologists could reasonably expect to achieve.

To some extent, the issue of technologists attaining professional licensure is complicated by the licensing exam itself. The most fundamental distinction between a professional and a paraprofessional is the professional's need to exercise discretionary judgment with respect to a body of abstract knowledge. But the current engineering licensing exam tends to emphasize relatively routine application of current code specifications, rather than the exercise of discretionary judgment. In this sense, the current licensing exam may be inadequate as a standard for practice at the professional level.

Implications of Ideology

Freidson's model identifies a *professional ideology* as one of the five principal characteristics of an ideal-typical profession. Because a profession can only exercise power through persuasion, ideology is a critically important tool for justifying the profession's privileged position in an economic system and for opposing the ideologies of the free market and the bureaucracy.

The ideology of an ideal-typical profession includes the following assertions:

- Professional work is intrinsically gratifying because it is interesting, challenging, and discretionary in nature. Compensation is not the professional's principal motivation for work. (This ideology is contrasted with free markets, in which work is inherently unpleasant, and people work only to make money; and bureaucracies, in which people work to maintain their positions in the firm.)
- Professional work requires the exercise of discretionary judgment in response to unique problems. Standardized solutions are not possible for the types of problems that professionals are called upon to solve.
- Professional work involves the application of esoteric concepts that are not easily understood by the consumer and are too complex to be managed by those who have only general knowledge.
- Professionalism entails service, not only to a client, but also to transcendent values. Service to transcendent values may require the professional to act against the immediate interests of the client, thus implying a certain independence of judgment rather than mere faithful service.

Freidson notes that medicine, law, and the clergy have attained the strongest public status as professions, in part because of their close association with the transcendent values of health, justice, and salvation. By contrast, the ideology of engineering is weak because "the only distinctive value to which the tasks of engineering can be attached is *efficiency*" (Freidson 2001, p. 171). Efficiency can only be a means to an end, and the outcome of an efficient process might just as easily be evil as good.

From the ideological perspective, civil engineers can certainly claim a close association with the transcendent values of public safety and quality of life. Indeed, ASCE has long emphasized the profession's contributions in these areas. Yet the profession's inability to gain broad public awareness of its association with these transcendent values remains problematic.

More recently, formal incorporation of sustainability into the civil engineering BOK represents the potential for further ideological gains. Sustainability is clearly associated with the well-being and long-term survival of humanity—a transcendent value of considerable appeal. It remains to be seen, however, whether the linkage between civil engineering and sustainability can be firmly established in the public mind.

Another important ideological dimension of the Policy 465 initiative is its leaders' refusal to associate higher professional standards with increased compensation for civil engineering professionals. This refusal is consistent with the ideological assertion that professionals are motivated primarily by the intrinsically interesting nature of their work. As Freidson demonstrates, a public perception that professional work is being done for economic self-interest can have a highly corrosive effect on the strength of the profession.

Role of Public Image

Public image is an important source of a profession's strength and, particularly in the United States, has often been decisive in establishing jurisdictional control. Indeed, professional jurisdictions are normally claimed and won in the public arena long before they are institutionalized in law (Abbott 1988, p. 70). A particularly interesting example can be seen in physicians' recent success in defining children's behavioral problems as a medical disease—hyperactivity—and then exerting jurisdictional control over it. This claim was won almost entirely in the public arena. Conversely, engineers' persistent inability to establish a clear, compelling public image is cited as another source of the engineering profession's inherent weakness (Freidson 2001, p. 168).

It follows, then, that ASCE's Raise the Bar initiative cannot be advanced solely within the professional and legislative communities. It is at least as important for enhanced professional standards to be sold to the general public through a comprehensive public information campaign.

Assault on Professionalism

Freidson (2001) and Krause (1999) describe an ongoing assault on professionalism, characterized by trends toward eliminating or weakening professional market shelters and standardizing professional work under the control of bureaucratic organizations. If these trends continue, Freidson predicts that

- Many tasks currently performed by professionals will be done by less-qualified workers;
- Many professional positions will be transformed into paraprofessional or nonprofessional positions;
- Expert knowledge will become increasingly commodified;
- Employing organizations will continue to standardize professional work to reduce costs and better control their workforces;
- Legal requirements for licensure will be relaxed or eliminated; and
- Within professional schools, curricula will face ever-greater demands for practical training, aimed at preparing students to perform specific tasks required in the workplace.

Many of these trends can be seen in the engineering profession today. Over time, design codes have become larger, more numerous, and increasingly prescriptive—in effect, substituting code specifications for the engineer's discretionary judgment. Recently, the governor of West Virginia proposed legislation that would allow state agencies to award engineering design contracts on the basis of competitive bids (Messina 2009). In 2008, the New York City Council eliminated the city's requirement that the commissioner of the Department of Buildings be a licensed engineer or architect. That same year, Nebraska initiated legislation to remove the requirement for the director of the Department of Natural Resources to be a licensed engineer. Despite the catastrophic collapse of the I-35 bridge in Minneapolis in 2007, state legislation that would require the deputy commissioner and chief engineer of the Minnesota Department of Transportation to be registered professional engineers is currently stalled (Boykin 2009). On the academic front, a recent report by the Carnegie Foundation for the Advancement of Teaching criticized engineering schools for "putting theory before practice" (Sheppard 2008)—a well-meaning criticism that inadvertently undermines the abstract theoretical basis for a strong professional BOK.

As Freidson suggests, the most important consequence of these deprofessionalizing trends will be a long-term decline in the quality of professional work because of reduced discretion, increased standardization, reduced job satisfaction among practitioners, and constraints on the development of new knowledge. Deprofessionalization will also weaken engineering ethics because only licensed professionals are subject to legally enforceable codes of ethics. For these reasons, above all, ASCE's ongoing efforts to strengthen the profession are imperative.

Conclusions

The analysis outlined previously yields the following three major conclusions:

- The sociological theories of Abbott and Freidson regarding professionalism are highly applicable to civil engineering. Most, if not all, of the significant challenges associated with Policy 465 implementation are addressed and informed by these theories. Many of the problems at which the initiative is aimed were well characterized by Abbott and Freidson long before they were articulated by ASCE. Thus, these models have great utility as an organizing framework for future efforts to advance the profession.
- In the context of ideal-typical professionalism, engineering is inherently weak. This weakness results from the nature of the discipline, the organizational context in which engineering work is usually performed, the exactness of the engineering BOK, and an ideology that can only claim efficiency as a transcendent value. For a variety of reasons, however, civil engineering appears to be an exception to this rule. As a result of its unique organizational context, its strong association with licensure, and the one-of-a-kind nature of its projects, civil engineering exhibits considerably greater consistency with ideal-typical professionalism than do most other engineering disciplines.
- With few exceptions, the Policy 465 initiative has tended to strengthen the civil engineering profession by moving it toward greater consistency with the ideal-typical model.

Recommendations

Specific recommendations for the future direction of Policy 465 implementation are provided subsequently. These recommendations do not reflect the author's opinions; rather, they derive logically and objectively from the foregoing analysis. Therefore, they describe actions that will strengthen the civil engineering profession by bringing it toward greater consistency with the Freidson's ideal-typical model. The recommendations are as follows:

- The published civil engineering BOK should remain a dynamic entity; thus, ASCE must be willing to continually update and refine it.
- The civil engineering BOK's enhanced emphasis on theoretical subjects (math, natural science, and engineering science), on master's-level technical specialization, on risk and uncertainty, and on inclusion of humanities and social sciences are sources of strength and should be preserved.
- Future editions of the published civil engineering BOK should emphasize the importance of university-based research in ensuring the vitality of the BOK.
- ASCE should continue using modifications to the ABET accreditation criteria as a mechanism for enhancing educational fulfillment of the BOK.
- ASCE's emphasis on professional licensure in general, and its ongoing efforts to raise licensure standards in particular, are critical to the strength of the profession and must be continued. The society should oppose industrial exemptions, which allow the practice of engineering without a professional license.
- ASCE should be prepared to proceed with the Raise the Bar initiative without the cooperation of other engineering societies, if necessary. The vast differences between the engineering disciplines and, in particular, the tendency of the manufacturing-oriented engineering disciplines toward bureaucratic control of their work will hinder long-term collaborative efforts to strengthen the engineering profession as a whole.
- On the other hand, it is critically important for ASCE to maintain strong collaborative relationships with professional organizations representing civil engineering subdisciplines (e.g., American Water Works Association, Institute of Transportation Engineers) and closely related engineering disciplines (e.g., American Academy of Environmental Engineers). Because these organizations are engaged in similar work and are similarly committed to professional licensure, their goals are more likely to be consistent with ASCE's goals.
- ASCE should continue to promote dialogue with its technical institutes over the future of the profession, recognizing that differentiation and disagreement over policy positions are inherent in professional organizations.

- ASCE should continue its efforts to define a distinct, valued, and clearly subordinate role for technologists. Separate credentialing of technologists would greatly enhance these efforts. The society should oppose any path to professional licensure that bypasses attainment of the professional BOK. The society should encourage NCEES to modify the engineering licensing exam to place more emphasis on the exercise of discretionary judgment with respect to abstract concepts and theories.
- ASCE should continue its strong emphasis on student activities as a mechanism for developing the professional identity of future engineers.
- ASCE's longstanding emphasis on the profession's role in enhancing public health, safety, welfare, and quality of life is appropriate from an ideological perspective. Efforts to strengthen this linkage in the public mind are imperative.
- The BOK's emphasis on sustainability represents an opportunity to greatly enhance the ideology of the civil engineering profession by associating its work with a transcendent value that is of considerable concern to society.
- ASCE should continue to pursue the Raise the Bar initiative without reference to its effect on monetary compensation for engineering professionals. To preserve the ideology of professionalism, economic gain must be viewed as secondary to the intrinsic satisfaction of professional work.
- ASCE should engage in a comprehensive public information campaign aimed at convincing all stakeholders, including the general public, that enhanced standards for engineering licensure will serve the public interest.
- Given their power, coherence, and broad applicability, the sociological models of professionalism by Abbott and Freidson should be used to guide the future strategic direction of the civil engineering profession.

References

Abbott, A. (1988). *The system of professions: An essay on the division of expert labor*, University of Chicago Press, Chicago.

American Academy of Environmental Engineers (AAEE). (2009). "Brief history." ⟨http://www.aaee.net/Website/BriefHistory.htm⟩ (Nov. 4, 2009).

American Academy of Environmental Engineers (AAEE) Environmental Engineering Body of Knowledge Working Group. (2008). "Environmental engineering body of knowledge: Summary report." *Environmental Engineer: Applied Research and Practice*, Summer.

American Council of Engineering Companies (ACEC). (2008). "ACEC opposes bachelor's plus 30 initiative: Little support found among members." *Last Word*, XXIX(19), 1.

American Society for Engineering Education (ASEE). (2006). "Resolution of the ASEE Engineering Deans Council, regarding removing the current prohibition on dual level accreditation." ⟨http://www.abet.org/Linked%20Documents-UPDATE/Dual/EDC%20Res%20on%20DualLevelAccreditation%20Ltrhd%201.pdf#search="engineering deans council dual level accreditation"⟩ (Nov. 12, 2009).

ASCE. (2004). *Civil engineering body of knowledge for the 21st century: Preparing the civil engineer for the future*, Reston, VA.

ASCE. (2007). "ASCE policy statement 465: Academic prerequisites for licensure and professional practice." ⟨http://www.asce.org/pressroom/news/policy_details.cfm?hdlid=15⟩ (Nov. 4, 2009).

ASCE. (2008). *Civil engineering body of knowledge for the 21st century: Preparing the civil engineer for the future*, 2nd Ed., Reston, VA.

ASCE. (2009). "Institutes/technical practice." ⟨http://www.asce.org/instfound/⟩ (Nov. 4, 2009).

ASCE Paraprofessional Exploratory Task Committee (PETC). (2008). "Final report to the ASCE BOD." ⟨http://www.asce.org/paraprofessionals/⟩ (Nov. 4, 2009).

Augustine, N. R. (2009). "Reengineering engineering." *PRISM Magazine*, Feb., 46–47.

Boykin, D. (2009). "A qualifications question: State societies are on the front lines working to prevent recent attempts to downgrade the status of the PE license." *PE Magazine*, Mar., 23–25.

Carr-Saunders, A. P., and Wilson, P. A. (1933). *The professions*, Oxford University Press, Oxford, UK.

Engineering Accreditation Commission (EAC). (2003a). "Criteria for accrediting engineering programs effective for evaluations during the 2004–2005 cycle." Accreditation Board for Engineering and Technology (ABET), Baltimore.

Engineering Accreditation Commission (EAC). (2003b). "Criteria for accrediting engineering programs effective for evaluations during the 2008–2009 cycle." Accreditation Board for Engineering and Technology (ABET), Baltimore.

Epstein, R. M., and Edward, H. M. (2002). "Defining and assessing professional competence." *J. Am. Med. Assoc.*, 287(2), 226–235.

Freidson, E. (2001). *Professionalism: The third logic—On the practice of knowledge*, University of Chicago Press, Chicago.

Gordon, B. M. (2007). "Engineering education must get real." *New England Journal of Higher Education*, Summer.

Grasso, D., et al. (2008). "Dispelling the myths of holistic engineering." *PE Magazine*, Aug./Sep., 26–29.

Grubbe, D. L. (2009). "Who will ultimately pay the bill?" *PE Magazine*, Mar., 15.

Holt, A. E. (2009). "Letter from the president, October 2009: P.E. licensing defined by public safety expectations." *ASME News*, 28(17).

Jacobson, L. (2009). "Professional licensing by the numbers." *PE Magazine*, May.

Johnson, A. T. (2009). "Defining the body of knowledge." Institute for Biological Engineering (IBE). ⟨http://www.ibe.org/engineering-for-life/body-of-knowledge.html⟩ (Nov. 12, 2009).

Krause, E. A. (1999). "Death of the guilds: Professions." *States, and the advance of capitalism, 1930 to the present*, Yale University Press, New Haven, CT.

Laity, W. W. (2004). "Body of knowledge—Mechanical engineering." American Society of Mechanical Engineers (ASME). ⟨http://files.asme.org/asmeorg/Education/College/ME/3949.pdf⟩ (Nov. 4, 2009).

Larson, M. S. (1977). *The rise of professionalism*, University of California Press, Berkeley, CA.

Lawson, W. D. (2004). "Professionalism: The golden years." *J. Prof. Issues Eng. Educ. Pract.*, 130(1), 26–36.

MacDonald, K. M. (1995). *The sociology of professions*, Sagè, Thousand Oaks, CA.

Messina, L. (2009). "Engineers blast Manchin's low-bid contract bill." *USA Today.* ⟨http://www.usatoday.com/news/nation/states/westvirginia/2009-03-18-138626079_x.htm⟩.

National Academy of Engineering (NAE). (2004). *The engineer of 2020: Visions of engineering in the new century*, National Academies Press, Washington, DC.

National Academy of Engineering (NAE). (2005). *Educating the engineer of 2020: Adapting engineering education to the new century*, National Academies Press, Washington, DC.

National Council of Examiners for Engineering and Surveying (NCEES). (2006). "News release: 9-25-2006. Council votes to increase amount of education required for engineering licensure." ⟨http://www.ncees.org/news/index.php?release_id=1⟩ (Nov. 4, 2009).

National Council of Examiners for Engineering and Surveying (NCEES) Engineering Education Task Force. (2009). "Analysis of the potential impact of requiring additional education for engineering licensure." NCEES, Seneca, SC.

National Council of Structural Engineers Associations (NCSEA). (2006). "Basic structural education." ⟨http://www.ncsea.com/Education/⟩ (Feb. 4, 2009).

New York State Education Department. (2009). "Education law: Article 145, professional engineering and land surveying." ⟨http://www.op.nysed.gov/article145.htm⟩ (Nov. 14, 2009).

Sheppard, S. D., et al. (2008). "Educating engineers: Designing for the future of the field." Carnegie Foundation for the Advancement of Teaching, Stanford, CA.

Snider, D. M., and Gayle, W. L. (2002). *Future of the army profession*, McGraw-Hill, Boston.

Teitelbaum, M. S. (2007). "Testimony of Michael S. Teitelbaum, Vice President, Alfred P. Sloan Foundation, before the Subcommittee on Technology and Innovation, Committee on Science and Technology U.S. House of Representatives, November 6, 2007." ⟨http://democrats.science.house.gov/Media/File/Commdocs/hearings/2007/tech/06nov/Teitelbaum_testimony.pdf⟩.

Timms, L. (2009). "Licensure exemptions limit boards' ability to protect public." *NCEES Licensure Exchange*, Apr., 5–6.

Weber, M. (1947). *The theory of social and economic organization*, Henderson and Parsons, New York.

Chapter 3

Civil Engineering in 2025: The Vision and How It Was Developed

Stuart G. Walesh, Ph.D., P.E., Dist.M.ASCE, D.WRE, F.NSPE, ***S. G. Walesh Consulting***

Michael J. Chajes, Ph.D., P.E., M.ASCE, ***University of Delaware***

David G. Mongan, P.E., F. ASCE, ***Whitney, Bailey, Cox, and Magnani, LLC***

Civil Engineering in 2025: The Vision and How It Was Developed

Abstract

In June 2006, a diverse group of civil engineering and other leaders, including international participants, gathered to articulate an aspirational global vision for the future of civil engineering. Summit participants saw a very different world for civil engineers in 2025. An ever-increasing global population that is shifting even more to urban areas will require widespread adoption of sustainability. Demands for energy, transportation, drinking water, clean air, and safe waste disposal will drive environmental protection and infrastructure development. Society will face increased threats from natural events, accidents, and perhaps other causes such as terrorism.

Informed by the preceding, an aspirational global vision was developed that sees civil engineers entrusted by society to create a sustainable world and enhance the quality of life. Civil engineers will do this competently, collaboratively, and ethically as master builders, environmental stewards, innovators and integrators, managers of risk and uncertainty, and leaders in shaping public policy.

Summit organizers and participants intend that the vision will guide policies, plans, processes, and progress within the civil engineering community and beyond including around the globe. Individual civil engineers and leaders of civil engineering organizations should act to move the civil engineering toward the vision.

Keywords – change, civil engineering, global, leadership, summit, vision

Introduction

Civil engineers are rightfully proud of their legacy. Over the past century, clean water supplies have extended general life expectancies. Transportation systems serve as an economic and social engine. New bridges, blending strength and beauty, speed transport and bring communities closer together. Public and private construction, for which engineers provide the essential underpinnings of design and project oversight, produces hundreds of thousands of jobs and drives community development. From the functional and beautiful Golden Gate Bridge in the U.S., Petronas Towers in Malaysia, and Pont du Gard in France to the largely hidden water supply and sanitary sewer systems, civil engineers have made their mark, day in and day out, in many aspects of the daily life of essentially everyone around the globe.

Civil engineers know they cannot rest on their laurels. An ever-increasing global population that continues to shift to urban areas will require widespread adoption of sustainability. Demands for energy, drinking water, clean air, safe waste disposal, and transportation will drive environmental protection and infrastructure development. Society will face increased threats from natural events, accidents, and perhaps other causes such as terrorism.

The Summit and Its Purpose

The Summit on the Future of Civil Engineering was convened in response to the status of, concerns with, and opportunities for the civil engineering profession. A highly-varied group of civil engineers, engineers from other disciplines, architects, educators, association and society executives, and other leaders, including participants from eight countries in addition to the U.S. (Australia, Canada, China, England, Japan, Mexico, South Africa, and Tunisia) attended. All gathered in Landsdowne, Virginia from June 21 to 23, 2006 to participate in the Summit.

The Summit's purpose was to articulate an aspirational global vision for the future of civil engineering addressing all levels and facets of the civil engineering community, that is, professional (licensed) civil engineers, non-licensed civil engineers, technologists, and technicians. The Summit's goal reflects the organizers' and the participants' preference of choice over chance. Statesman William Jennings Bryan highlighted those options when he said: "Destiny is not a matter of chance; it is a matter of choice." Broadly speaking, there are only two futures for civil engineering around the globe; the one the profession creates for itself or, in the void, the one others create for civil engineering. Civil engineers came to the Summit to choose their profession's future.

Process Used to Plan, Facilitate, and Follow-Up on the Summit

The idea of holding a Summit on the Future of Civil Engineering surfaced a number of years ago with detailed planning beginning in earnest in the summer of 2005. A Task Committee (TC) representing various elements of industry, government, academia, age, and gender was selected to plan, conduct, and report on the Summit. The individuals on the TC were chosen because of their past involvement in discussions about a Summit as well as their expertise in conducting strategic planning efforts and similar activities.

The first major task of the committee was to define the format for the Summit which was determined to be a series of facilitated roundtables on various topics. The Summit would begin with an overall vision of the future provided by a noted futurist. Each roundtable would be preceded by an invited presentation on a specific topic and a concluding Summit activity would focus on crafting a series of visions.

Stephen Bechtel, Jr. and Patricia Galloway were invited to serve as honorary co-chairs of the Summit. Parallel to the Task Committee's activities, the ASCE Foundation began an effort to raise the necessary funds to conduct the Summit. Supporters of the Summit on the Future of Civil Engineering, without whom this gathering would not have been possible, were: Stephen D. Bechtel, Jr.; AECOM; ASCE Foundation; B & E Jackson & Associates; The Charles Pankow Foundation; CH2M HILL; DuPont; Fluor Corporation; Judith Nitsch Engineering, Inc.; The Port Authority of New York/New Jersey; University of Illinois at Champaign-Urbana; and Whitney, Bailey, Cox & Magnani, LLC

To support Summit planning, ASCE conducted an e-mail survey of the membership to determine their opinions on aspirations and visions for civil engineering in 2025. The Summit could only accommodate a limited number of individuals, so ASCE believed it was important to solicit the opinions of a wide selection of the membership in order to ensure broader input to the Summit discussions.

ASCE received 4,382 valid responses to the survey. Respondents were demographically representative of the entire spectrum of the ASCE membership. The results included over 12,000 individual written comments submitted in response to the questions asked. The information was tabulated and used by the TC in planning for the Summit.

Invitations were extended to approximately 60 individuals selected to provide as diverse as possible representation at the Summit. The TC sought representation from large, medium, and small consultants; industry and government (both federal and local); academia; entities from other nations; technologists; architects; contractors; and younger members. Prior to the Summit, each invitee received four mailings of reports and other materials to help prepare them for the conference. This includes an annotated bibliography, a refined version of which is Appendix A.

The TC researched and discussed the meaning of vision. Some vision definitions discovered during this process are:

- "A mental model of a future state of a process, a group, or an organization."[1]
- "A cognitive image of the future which is positive enough to members so as to be motivating and elaborate enough to provide direction for future planning and goal setting."[2]
- "A mental image of something that is not perceived as real and is not present to the senses" "…produced by the imagination."[3]
- "An image (not just an idea) of an attractive (compelling) future state unique to a group, organization, or community that gives meaning to effort [and] motivates people to work together in the turmoil of a changing world."[4]
- "A useful vision statement answers these questions: How will we be different or better? What new roles or areas will we cover? What new measures of success will we have achieved?"[5]

Based on input like the preceding, "vision" as used at the Summit and in this report is mental, cognitive—not reality, or even close to reality, as we know it today. It is influenced, at least in part, by imagination, reflective of actual or desired values, and focused on "what," not "how." Finally, a vision is stimulating, energizing, engaging, and inclusive. In contrast, a vision is not, and does not contain, the means to achieve it. Nor is a vision the next logical or evolutionary improvement in a process, group, or organization, as important as that may be. This understanding of vision was shared with Summit participants.

A key factor in the Summit's success was the use of ASCE staff as trained facilitators. In addition to the primary facilitator, a secondary facilitator served as a recorder. Facilitators prepared by reading the advance material sent to the Summit participants and by participating in training which included separate mock facilitation session.

The TC believed that the traditional process of having a report after each breakout by a member of each breakout group would not be effective. Having a recorder take real time notes allowed the creation of theme teams. Each theme team consisted of four members of the TC and after each of the breakouts, a theme team met and, using the notes from the various breakout tables, compiled a consolidated report. That report was then presented to a plenary session for feedback and comments. This process was very effective and captured a great deal of information.

Immediately after the conclusion of the Summit, the TC met to review the information and determine the next steps for writing the report. Writing and other tasks were assigned and a schedule for completion of the initial document was established.

Once the draft report was completed, it was circulated to the Summit participants for their review and comment. A final draft[6] was reviewed by a wider audience, both within and outside of ASCE. A final report, reflecting the results of that wide review, will be issued in 2007.

Vision

The Summit produced a series of aspirational visions stimulated by participant views of the world of 2025. The resulting integrated global aspirational vision is:

Entrusted by society
to create a sustainable world and
enhance the global quality of life,
civil engineers
serve competently, collaboratively, and ethically as master:

- **planners, designers, constructors, and operators of society's economic and social engine, 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**

- l**eaders in discussions and decisions shaping public environmental and infrastructure policy.**

As used in the vision, "master" means to possess widely-recognized and valued knowledge and skills and other attributes acquired as a result of education, experience, and achievement. Individuals, within a profession, who have these characteristics are willing and able to serve society by orchestrating solutions to society's most pressing current needs while helping to create a more viable future.

Profile of the 2025 Civil Engineer

The Summit addressed this question: What could civil engineers be doing in 2025? Addressing this second question naturally led to describing the profile of the 2025 civil engineer, that is, the attributes possessed or exhibited by the individual civil engineer of 2025 consistent with the preceding aspirational vision for the profession.

Attributes may be defined as desirable knowledge, skills, and attitudes. As used here, knowledge is largely cognitive and consists of theories, principles, and fundamentals. Examples are geometry, calculus, vectors, momentum, friction, stress and strain, fluid mechanics, energy, continuity, and variability.

In contrast, skills refer to the ability to do tasks. Examples are using a spreadsheet; continuous learning; problem solving; critical, global, integrative/system, and creative thinking; teamwork; communication; and self-assessment. Formal education is the primary source of knowledge as defined here, whereas skills are developed via formal education, focused training, and certain on-the-job experiences.

Attitudes reflect an individual's values and determine how he or she "sees" the world, not in terms of sight, but in terms of perceiving, interpreting, and approaching. Examples of attitudes conducive to effective professional practice are commitment, curiosity, honesty, integrity, objectivity, optimism, sensitivity, thoroughness, and tolerance. The Summit identified many and varied attributes, organized into the preceding knowledge, skills, and attitudes categories. The results are presented here.

The civil engineer is **knowledgeable**. He or she understands the theories, principles, and/or fundamentals of:

- **Mathematics, physics, chemistry, biology, mechanics, and materials** which are the foundation of engineering
- **Design** of structures, facilities, and systems
- **Risk/uncertainty** such as risk identification, data-based and knowledge-based types, and probability and statistics
- **Sustainability** including social, economic, and physical dimensions
- **Public policy** and **administration** including elements such as the political process, laws and regulations, funding mechanisms
- **Business basics** such as legal forms of ownership, profit, income statements and balance sheets, decision or engineering economics, and marketing
- **Social sciences** including economics, history, and sociology
- **Ethical behavior** including client confidentiality, codes of ethics within and outside of engineering societies, anti-corruption and the differences between legal requirements and ethical expectations, and the profession's responsibility to hold paramount public health, safety, and welfare

The civil engineer is **skillful**. He or she knows how to:

- **Apply basic engineering** tools such as statistical analysis, computer models, design codes and standards, and project monitoring methods
- **Learn about, assess, and master new technology** to enhance individual and organizational effectiveness and efficiency
- **Communicate** with technical and non-technical audiences, convincingly and with passion, via listening, speaking, writing, mathematics, and visuals
- **Collaborate** on intra-disciplinary, cross-disciplinary, and multi-disciplinary traditional and virtual teams
- **Manage** tasks, projects, and programs so as to provide expected deliverables while satisfying budget, schedule, and other constraints
- **Lead** by formulating and articulating environmental, infrastructure, and other improvements and build consensus by practicing inclusiveness, empathy, compassion, persuasiveness, patience, and critical thinking

The civil engineer embraces **attitudes** conducive to effective professional practice. He or she exhibits:

- **Creativity** and **entrepreneurship** that leads to proactive identification of possibilities and opportunities and taking action to develop them
- **Commitment** to ethics, personal and organizational goals, and worthy teams and organizations
- **Curiosity** which is a basis for continued learning, fresh approaches, development of new technology or innovative applications of existing technology, and new endeavors
- **Honesty** and **integrity**, that is, telling the truth and keeping one's word.
- **Optimism** in the face of challenges and setbacks recognizing the power inherent in vision, commitment, planning, persistence, flexibility, and teamwork
- **Respect** for and **tolerance** of the rights, values, views, property, possessions, and sensitivities of others
- **Thoroughness** and **self-discipline** in keeping with the public health, safety, and welfare implications of most engineering projects and the high-degree of interdependence within project teams and between such teams and their stakeholders

Many of the preceding attributes are shared with other professions. Civil engineering's uniqueness is revealed in how the attributes enable the profession to do what it does and, more importantly, to become what it wants to be. This is inherent in the global aspirational vision.

Student Response

Forty-four University of Delaware first-year engineering students in the Introduction to Engineering class were asked to read a draft of the Summit report and write a one to two-page essay. Topics to be addressed in the essay were the aspirational vision, the portrayal of the civil engineer's world of 2025, and the report as a whole. A sampling of comments from different students follow:

"I commend the selected civil engineers for trying to be prepared and ahead of the game."

"This vision seems to make civil engineers out to be one of the most important professions in society."

"It amazes me that civil engineers can come together… to create goals that will benefit the entire community."

"I personally would like to be a part of this field because I know I will get the chance to make an impact on society and help people."

"The civil engineer is a truly amazing person… intelligent, charismatic, and powerful."

"I had no idea how important civil engineering was, and from what I have heard, seen, and read from this class and this report, I am definitely leaning towards this specific area of engineering."

Professor Michael Chajes, who taught the course, reported that "the students were virtually unanimous in liking the report." Chajes stated that "we have developed a document that captures the imagination of young engineers."

Perhaps the final report, or summaries of it, can be used to more fully inform prospective and current civil engineering students, parents and counselors of pre-college students, and others about the civil engineering profession of today, and more importantly, tomorrow.

What Next?

The aspirational vision presented in the vision report represents a beginning—the springboard to launch a sustainable, influential process so that the vision for civil engineering in 2025 can be attained. The Summit's sole goal was to define this aspirational vision; it was not to create the roadmap on how to achieve it. That map-making begins now.

The vision gives leaders a target to guide their policies, plans, processes, and progress on a broad and diverse front, within and outside the engineering community. In moving forward, leaders in the civil engineering community should recognize that:

- A variety of partners must be engaged, and opportunities for collaboration and action identified.

- The international engineering community must also be engaged to maximize the reaches of the vision to the global civil engineering community.

- The public and policy-makers must be engaged so that the profession serves society to the fullest.

- The education and training of future civil engineers and the continued development of today's civil engineers must include and go beyond the required technical competencies.

Forging a long-term action plan to achieve the vision will require input and cooperation from a diverse group of leaders and organizations. Individual leaders within the civil engineering community must build awareness and excitement for achieving the vision. Additionally, civil engineering organizations have to create momentum toward the attainment of the vision within their organizations. Specific opportunities to present the vision for 2025 at board meetings, annual conferences, and the like must be identified and pursued. Organizations need to share knowledge and work together to make measurable progress toward the vision.

In addition to technical and professional organizations, client-related organizations must also be engaged. Finally, civil engineers must also engage the public—the primary beneficiaries of civil engineering services. Such efforts among individuals and organizations around the world will be key to the achievement of the vision.

Several aspects of the vision relate to the civil engineer's interaction with the public. Civil engineers aim to be—and be perceived as—trusted advisors to the public and policy-makers regarding infrastructure. To accomplish this, civil engineers must show the public how their services daily touch the public and improve lives. In particular, the civil engineering community must increasingly seek opportunities to use its abilities to improve the quality of lives in more areas of world. Now is the time to develop workable and economically-feasible solutions to the world's infrastructure needs. The public must be engaged in this continuing process to raise the quality of infrastructure.

Today's civil engineers will need to transform themselves to meet the challenges of tomorrow. They must stay abreast of changing technologies, market trends, and business developments. Moreover, they must cultivate the new technologies, direct the market, and develop new business practices to lead the transformation into tomorrow.

Educating future civil engineers is also an essential component of the vision for the civil engineering profession in 2025. Fulfilling the vision requires an expanded set of knowledge, skills, and attitudes, highlighting the need for curricula reform today to develop that knowledge and those skills and attitudes needed in 2025. Colleges and universities must examine their curricula as they relate to the future civil engineer so advancement toward the vision can be realized. Similarly, experienced engineers should coach and mentor younger engineers, especially during the pre-licensure period, with the goal of enhancing knowledge, skills, and attitudes acquired during formal education.

U.S. civil engineers can be catalysts in sharing the vision with the global civil engineering community. The surest path to success is the integration of knowledge from civil engineers within a broad range of economies, cultures and circumstances. Conferences conducted by international engineering groups, such as the World Federation of Engineering Organizations, are excellent vehicles for obtaining concurrence and determining a direction for the international civil engineering profession of 2025.

Collective, long-term actions to help achieve the vision might include:

- A more robust educational path for civil engineers that prepares them for leadership and provides the multifaceted non-technical skills to serve on projects affecting the public good.
- A more clearly defined organizational structure for the engineering team, where the licensed civil engineer takes on the role of master program/project integrator.
- More civil engineers involved in public policy forums where future directions for society are developed and where civil engineers can gain the public's trust.
- More civil engineers elected to public office where they can directly influence infrastructure and sustainability policy and legislation.
- A greater level of collaboration and communication among civil engineers and those non-engineer stakeholders, seeking to balance a sustainable environment with needed infrastructure.
- Increased research and development to mitigate the effects of natural disasters, with civil engineers playing a leading role in devising and implementing the innovations.
- Greater education and training of engineers in ethics and a greater emphasis on ethics in global engineering practice, allowing engineers to serve as role models.
- Sharing the vision with pre-college students, and their parents and counselors, to better inform them about the profession and thus attract even more of the best and the brightest to the profession.

Summit organizers hope that these first sketches of possible action will cause individual members of the civil engineering community to contemplate how they, their organizations, and their countries can begin planning and implementing the next steps to making this vision a reality. This will be no small task. However, a united civil engineering community can start the hard work that will ultimately fulfill that promise.

Acknowledgements

The authors gratefully acknowledge the many and varied efforts of members of the Task Committee, Summit participants, ASCE staff, and report reviewers.

Appendix A

Prior to the Summit on the Future of Civil Engineering, participants received selected documents and annotations of books, reports, articles and other resources relevant to some aspect of the future. These materials are presented here, largely as they were sent to the participants, for possible use by others.

- ASCE Task Committee to Plan Conference on Civil Engineering Research Needs, 1988. ***Civil Engineering in the 21st Century: A Vision and a Challenge for the Profession***,

ASCE, Reston, VA. (12 pages). (Suggests changes in practice, education, research, policy. This is the most recent ASCE vision report prior to the June 2006 Summit.)

- ASCE Body of Knowledge Committee, 2004. ***Civil Engineering BOK for the 21st Century***, ASCE, Reston, VA. Executive Summary (8 pages). (Prompts thought about where we ought to prepare civil engineers for entry into the practice of civil engineers as viewed by an increasing number of educators and practitioners.)

- ASME Council on Education, 2004. **"A Vision of the Future of Mechanical Engineering Education,"** ASME, November. (Cites the need for critically examining engineering education. Indicates that mechanical engineering is moving from "generation and application of heat and mechanical power and the production design, and use of machines and tools" to addressing "societal concerns through analysis, design, and manufacture of systems.")

- Barker, J. A., 1989. ***Discovering the Future: The Business of Paradigms***, ILI Press, St. Paul, MN. (Warns of the danger of paradigm paralysis and advocates paradigm pliancy. Provides many examples of dramatic paradigm changes.)

- Birnberg, H., 2002. **"Forecast 2000/2001 and Beyond,"** *Engineering Times*, NSPE, Vol. 22, No. 3, March. (Predicts increased emphasis on project managers in design and construction organizations apparently due to increased project complexity, expanded outsourcing of design and construction, more use of independent contractors in the private sector to match fluctuating work loads, continued consolidation of E/A firms, growth in design-build, higher service expectations, expanded web-based project management, and even broader role for civil engineers. The author is Executive Director of the Association for Project Managers.)

- Bradley, R. M., 2005. **"Survival of International Civil Engineering Consultancies: The Need to Adjust to Reality,"** *Leadership and Management in Engineering - ASCE*, October. (Describes the challenges faced by American civil engineering consulting firms trying to operate successfully in developing countries given that indigenous firms are acquiring the knowledge and skills needed to do most of the engineering. Success requires improved productivity and greater localization.)

- Center for Strategic and International Studies, 2006. **"Seven Revolutions: What Will the World Look Like in 2025?"** http://www.7revs.org/sevenrevs_content.html. (This website explores these seven revolutions or drivers of change: population, resources and the environment, technology, knowledge, economics, conflict, and governance. Leaders can use this website to expand and stimulate their thinking and that of their colleagues.)

- Collins, J., 2001. ***Good to Great***, Harper-Collins, New York, NY. (Argues that having the right people "on the bus," engaged in frank, open-minded, out-of-the-box thinking is a key to developing ideas and strategies for a successful future. Honest evaluation and informed discussion will yield continuous improvement. Notes that true leaders are steady, consistent, non-flashy individuals with vision, tenacity, and long-term patience.

They are passionate about their organization and are willing to pay the price for improvement and share the glory with others. They see the big picture, are willing to hear and digest facts, and aren't driven by short-term gain.)

- Diamond, J. M., 2005. ***Collapse: How Societies Choose to Fail or Succeed***, Penguin Books, New York, NY. (Analyses five ancient, collapsed, societies and four ancient, surviving, societies, each beset with ecological crisis; lays the groundwork for understanding the importance of the crucial choices made by those populations; and offers a perspective for the problems plaguing our modern world. Because globalization now makes it impossible for societies to collapse in isolation, these insights into some of the deepest mysteries of the past offer hope for the future and a framework for our decisions and actions.)

- *Engineering Times*, 2000. **"Engineers, Scientists Share Their 2020 Vision,"** February. ("Engineers and scientists at Battelle predict that the next two decades will bring a world of microscope cancer-eating machines, personalized public transportation, energy and green technology revolutions, cloned human organs, intelligent appliances, and computers everywhere, maybe even embedded in our clothes or under our skin.")

- Friedman, T. L., 2005. ***The World is Flat***, Farrar, Stauss and Giroux, New York, NY. (New technologies, new business practices, and new players are converging globally and will markedly change the way business is conducted. Chapter 6 suggests loss of American dominance partly because fewer young people are pursuing mathematics, science, and engineering careers and because of a decline in ambition of American youth relative to counterparts in other countries.)

- Graham, L. R., 1993. ***The Ghost of the Executed Engineer: Technology and the Fall of the Soviet Union***, Harvard University Press, Cambridge, MA. (Argues that the Soviet Union failed to become a modern industrialized country, in spite of its vast natural resources and huge number of engineers, because of "misuse of technology and squandering of human energy," including its engineering talent, until its demise at the end of 1991. As the U.S. increasingly participates in a global economy, might our country's self interest be better served if we more fully utilized our engineering talent? Maybe we can learn a lesson from the Soviets who did not practice good stewardship with their engineers.)

- Heenan, D. A., 2005. ***Flight Capital: The Alarming Exodus of America's Best and Brightest,*** Davies-Black, Mountain View, CA. (Describes how emerging economies are luring their native born, highly-educated professionals from the U.S. back to their home countries. Outlines 12 actions the U.S. could take to reverse the "brain drain.")

- Minnesota Supreme Court, 2004. **"Professional Aspirations: Aspiration Standards of Conduct for the Bench and Bar of Minnesota,"** January. (Memorializes the obligations of lawyers and judges to the legal system, to clients, to each other, and to citizens. Stresses values and attributes including respect, dignity, honesty, education, judgment, civility, courtesy, cooperation, and punctuality.)

- National Academy of Engineering, 2004. ***The Engineer of 2020: Visions of Engineering in the New Century***, Washington, D.C. (Concludes that if the engineering profession wants to determine its future, the profession must agree on a vision, transform engineering education, present engineers as broad-based technology leaders, accommodate innovations from non-engineering fields, and become more interdisciplinary.)

- National Academy of Engineering, the National Academy of Sciences, and the Institute of Medicine, 2006. ***Rising Above the Gathering Storm: Energizing America for a Brighter Future – Executive Summary***, Washington, D.C. (Warns that the U.S. increasingly risks losing jobs to global competitors and advocates more mathematics, science, research, and innovation.)

- Rogers, M., 2002. **"The Practical Futurist: Boiling the Ocean,"** *Newsweek*. (Observes that, because of the increasing rate of technologic change, "the future happens much more quickly" and concludes that "we're all futurists now—practical futurists, trying to map the shortest path between today and a point not that far in the distance.")

- Silberglitt, R., P. S. Antón, D. R. Howell, and A. Wong, 2006. ***The Global Technology Revolution 2020, In-Depth Analyses***, Technical Report, RAND National Security Division. (Reports on the results of a study that identified "technologies and applications that have the potential for significant and dominant global impacts by 2020.")

- **The World Future Society**, http://www.wfs.org. (The World Future Society is "an association of people interested in how social and technological developments are shaping the future." Publishes the bi-monthly *The Futurist*.)

- Toffler, A., 1980. ***The Third Wave***, Bantam Books, New York, NY. (Describes three types of societies and, using waves as a metaphor, claims that each successive society pushes the preceding one aside. The First Wave Society is the agrarian which replaced the hunter-gatherer culture. The Second Wave Society is the "mass" culture, that is mass production, distribution, consumption, education, media, recreation, entertainment, and weapons of destruction. This "mass" model is now being replaced by the Third Wave, the post-industrial society. This wave is characterized by ready access to information, diverse life styles, fluid organizations, and customization. Toffler also authored *Future Shock*, (1970).)

Note: Many individuals helped identify resources listed in the Annotated Bibliography. The assistance of the following is gratefully acknowledged: Richard O. Anderson, SOMAT Engineering; Neil Grigg, Colorado State University; W. M. Hayden, Management Quality by Design; Robert Houghtalen, Rose-Hulman Institute of Technology; Thomas A. Lenox, ASCE; Blaine Leonard, Utah Department of Transportation; Rick McCuen, University of Maryland; and Stuart G. Walesh, Consultant.

Bibliography

1. From Burt Nanus, management consultant as quoted on http://www.heavypen.com/vision/index.html, April 5, 2006.
2. From management researchers Peg Thomas and David Greenberger as quoted on http://www.heavypen.com/vision/index.html, April 5, 2006.
3. http://www.thefreedictionary.com/vision, April 11, 2006.
4. http://www.iastate.edu/~vision2020/Phase1/b5b/B5aPeter.html, April 11, 2006.
5. Hensey, M., *Continuous Excellence: Building Effective Organizations*, Reston, VA: ASCE Press, 1995.
6. ASCE Task Committee to Plan a Summit on the Future of the Civil Engineering Profession, *The Vision for Civil Engineering in 2025,* Final draft, Reston, VA: ASCE, January 12, 2007 (For the current draft, contact Editor S. G. Walesh, Stuwalesh@comcast.net)

/VisionofCE2

Chapter 4

The New and Improved Civil Engineering Body of Knowledge

Richard O. Anderson, P.E., Dist.M.ASCE, ***Somat Engineering***

Stuart G. Walesh, Ph.D., P.E., Dist.M.ASCE, D.WRE, F.NSPE, ***S. G. Walesh Consulting***

Kenneth J. Fridley, Ph.D., F.ASCE, ***University of Alabama***

Originally published as "The New and Improved Civil Engineering Body of Knowledge," in *Proceedings of the 2008 Conference of the American Society for Engineering Education*, June 2008.

The New and Improved Civil Engineering Body of Knowledge

Abstract

In January 2004 the American Society of Civil Engineers (ASCE) published the Civil Engineering Body of Knowledge for the 21st Century report (BOK1)[1]. Based on the favorable reception of the BOK1 in the civil engineering community, ASCE embarked on a revision of the BOK to take advantage of the comments received and the lessons learned in early implementation of the BOK1. Late in 2005 ASCE initiated the Second Edition of the Body of Knowledge Committee (BOK2Cmte) under the auspices of the Committee on the Academic Prerequisites for Professional Practice (CAP^3). The BOK2Cmte committee started with what had been accomplished in implementation of the BOK1 but with no preconceived notions on what should be included or excluded from the civil engineering Body of Knowledge. The committee initiated the revision of the BOK by identifying over 30 topics as candidates for inclusion in the new BOK, including the 11 from the ABET/EAC. Through a rigorous process, the desired level of achievement of each of the topics, or outcomes, was determined according to Bloom's Taxonomy of the Cognitive Domain. The number of outcomes was eventually whittled down to a comprehensive, coordinated list of 24 outcomes divided into three outcome categories; Foundational, Technical and Professional. In addition, the level of achievement expected to be achieved prior to entry into the professional practice of civil engineering is identified for each outcome. Each of the Bloom's levels of achievement for each outcome is also assigned to a stage in the young engineer's career, from the baccalaureate degree program, to post-baccalaureate formal education, to pre-licensure working experience. Next, the BOK2 will be reviewed by a new committee, the BOK Educational Fulfillment committee, which will assemble best practices for use in fulfilling the BOK through formal education.

Introduction

In February 2008 the American Society of Civil Engineers (ASCE) published the Second Edition of the Civil Engineering Body of Knowledge (BOK2)[2]. The publication of this document is the culmination of over two years of research, study and hard work by the Second Edition of the Body of Knowledge Committee (BOK2Cmte). The Second Edition of the BOK document has built on the content and success of the First Edition and gone beyond in terms of content, clarity, and responsibilities.

For the purposes of this paper, the following terminology is used:

BOK = Civil Engineering Body of Knowledge

BOK1Cmte = The ASCE/CAP^3 committee charged with developing the first edition of the report on the BOK

BOK1= The report developed by the BOK1 committee, Reference 1

BOK2Cmte = The ASCE/CAP^3 committee charged with developing the second edition of the report on the BOK

BOK2= The report developed by the BOK2 committee, Reference 2

Improvements to the Second Edition relative to the First Edition include a better system of identifying the level of achievement (as opposed to the level of competence) expected of the engineering student and the young practicing engineer, a system of allocating responsibility and the timing of that responsibility for achievement of the respective outcomes, and more clarity in the comprehensive, coordinated list of 24 outcomes that will be required for entry into the professional practice of civil engineering in the 21st Century.

First Edition of the Civil Engineering Body of Knowledge

The First Edition of the Civil Engineering Body of Knowledge (BOK1)[1] report was published by ASCE in January 2004. The essence of the BOK1 was the 15 outcomes, the attainments of which were defined as prerequisites for entry into the professional practice of civil engineering in the 21st Century. This document leaned heavily on the ABET General Criteria as developed by the Engineering Accreditation Commission of ABET (ABET/EAC)[3]. Nominally, eleven of the fifteen outcomes identified in the BOK1 were directly related to the ABET/EAC General Criteria 3(a-k).

"In addition to the 11 ABET outcomes, which are included verbatim in the 15 BOK outcomes, four entirely new outcomes (Outcomes 12-15) address technical specialization, project management, construction, asset management, business and public policy and administration, and leadership." [1]

Upon embarking on the BOK1, ASCE was cognizant that this would be a long-term iterative learning process and subsequent work would be required. The BOK1 was successful in stimulating dialogue amongst civil engineers and within the engineering community at-large. ASCE promoted this dialogue by presenting or attending many forums in which the BOK1 was discussed, challenged, dissected, and critiqued. ASCE recorded and catalogued the content of these forums in full anticipation that some day a Second Edition would be required. Because of the richness of these conversations on the BOK1, that day came sooner than many expected. The BOK has evolved into a process to help achieve the ASCE aspirational vision that is strategic, future focused, and comprehensive. It is a dynamic document and not a static, backwards looking document.

In addition, parallel to, but completely independent of, the ASCE BOK efforts, other engineering groups were also evaluating the changes needed in engineering education and practice for the 21st Century. These evaluations included the seminal studies from the National Academy of Engineering (NAE), "The Engineer of 2020"[4] and "Educating the Engineer of 2020[5]. A broader constituency was energized with the NAE national call to action "Rising Above the Gathering Storm" [6]. This document presented a roadmap for engineering and science for what the nation needs to do to maintain our eminence in these fields. The publication of these studies by the NAE opened the discussion to a much wider audience with a broader agenda. And, coincidentally, they lent credibility and urgency to the ASCE efforts to reform civil engineering education in preparation for the changing requirements of the new century.

ASCE Vision

In June 2006, a diverse group of civil engineering and other leaders, including international participants, gathered to articulate an aspirational 2025 global vision for the future of civil engineering. Participants in this Summit on the Future of Civil Engineering saw a very different world for civil engineers in 2025. An ever-increasing global population that is shifting even more to urban areas will require widespread adoption of sustainability. Demands for energy, transportation, drinking water, clean air, and safe waste disposal will drive environmental protection and infrastructure development. Society will face threats from natural events, accidents, and perhaps other causes such as terrorism.[7]

Informed by the preceding, an aspirational global vision was developed that sees civil engineers entrusted by society to lead in the creation of a sustainable world and enhancing the global quality of life. The report resulting from this vision setting gathering, "The Vision for Civil Engineering in 2025"[7], provided further input for the revision of the BOK1. In fact there was significant potential synergism between the Vision and the BOK efforts.

Second Edition of the Civil Engineering Body of Knowledge

Based on the groundswell of opinions and the plethora of reports and studies that indicated the time for engineering education reform has come, ASCE elected in 2005 to revise the BOK1 to reflect the consensus that had developed since the development of the BOK1. Thus, in late 2005 the Second Edition of the Civil Engineering Body of Knowledge Committee (BOK2Cmte) was formed for the specific purpose of revising the BOK1 to reflect all that had happened in this arena in the intervening years.

BOK2Cmte was formed as a constituent committee of the Committee on the Academic Prerequisites for Professional Practice (CAP^3), the Board level committee charged with the implementation of ASCE Policy Statement 465. An open call for potential committee members was made, and as a result, appointment to the 14 funded positions on the BOK2Cmte was very competitive. The result was that the diversity inherent in the ASCE membership was maintained so that all sectors of the ASCE membership had a voice. In addition, because there were far more applicants than funded positions available, other interested people were invited to be corresponding members. A total of about 50 people ultimately signed on to become corresponding members, with approximately 10 of those from outside of the United States. These 50 people were primarily civil engineers, but some represented other engineering disciplines, and some were not even engineers, such as training and professional development staff people from large engineering organizations. Both the funded committee members and the corresponding members had representatives from academia, industry and governmental sectors.

The agenda for the BOK2Cmte was large and intimidating. Most of the work of the BOK2Cmte was conducted via 65 telephone conference calls for the main committee, and probably an equal number of conference calls for the various task committees. The task committees were formed as needed to research and prepare position or background papers on specific topics that helped to define the potential outcomes. In addition, four face-to-face meetings were held. The corresponding members served on the task committees and participated in e-mail discussions as well as some of the telephone conference calls. Over 15 drafts of the BOK2 were eventually developed and circulated.

The BOK2Cmte started out by performing a thorough review of the BOK1, the NAE reports, ABET requirements, bodies of knowledge from other professions, and the comments received from ASCE members and others in and outside of the general engineering community. From review of this information, it was evident to the BOK2Cmte that there was room for improvement in the BOK1, but there was also the realization that the BOK2 could not be all things to all people.

Outcomes and the Organization of BOK2

After the BOK2Cmte had thoroughly reviewed the available information, the committee identified over 30 topics that were initially considered to be suitable for inclusion as outcomes. Although both the ABET criteria and the BOK1 and the BOK2 use the term outcome, there is a difference between the ABET use of the word and the BOK use of the word. ABET defines an outcome as: "*…program outcomes are statements that describe what students are expected to know and be able to do by the time of graduation.*".[3] The ASCE BOK definition of an outcome is: "*Statements that describe what individuals are expected to know and be able to do by the time of entry into the practice of civil engineering at the professional level in the 21st Century. Outcomes define the knowledge, skills, and attitudes that individuals acquire through appropriate formal education and pre-licensure experience.* ".[2] There is significant overlap in the ABET outcomes and the BOK2 outcomes, which is to be expected because 11 of the 15 outcomes in the BOK1 came directly from ABET/EAC General Criteria 3 (a-k)[3].

Over the BOK2Cmte's term of service, the number of outcomes was whittled down from 30+ to 24 by combining some and eliminating others. The number itself is not nearly as important as the content, the clarity, and the impact of the individual outcomes. There are relatively few "new" outcomes in the list of 24 relative to the BOK1. Appendix A of this paper contains a chart that shows the genealogy of the 24 outcomes of BOK2 starting with the ABET/EAC 11. In fact, many of the ABET/EAC 11 were derived from a document from the early 90's titled "Desired Attributes of an Engineer"[8] , as developed by the Boeing Corporation. Boeing was very active in engineering education, and along with several other large industrial employers of engineers, was instrumental in focusing attention on the need to reform the ABET accreditation process and criteria, resulting in the outcomes based assessment system now used by ABET.

The 24 outcomes have been arranged in three categories: Foundational, Technical, and Professional. The outcome titles in each are as follows:

Foundational

1. Mathematics
2. Natural Sciences
3. Humanities
4. Social Sciences

Technical

5. Materials Science
6. Mechanics

7. Experiments
8. Problem Recognition and Solving
9. Design
10. Sustainability
11. Contemporary Issues & Historical Perspectives
12. Risk and Uncertainty
13. Project Management
14. Breadth in Civil Engineering Areas
15. Technical Specialization

Professional

16. Communication
17. Public Policy
18. Business and Public Administration
19. Globalization
20. Leadership
21. Teamwork
22. Attitudes
23. Life-Long Learning
24. Professional and Ethical Responsibility

The importance of an outcome in a typical civil engineering curriculum cannot be inferred by its stand-alone presence or order in the table. Substantially more time will by spent by the students in Problem Recognition and Solving, or Design, than on Globalization or Public Policy, but they are all separate outcomes with varying levels of achievements expected of the students and/or young practitioners.

Several of the outcomes resulted from disaggregation of broader outcomes in either the ABET/EAC 11, or the BOK1. This was done primarily for the sake of clarity and recognition that the combined outcomes need to be disaggregated in order to properly highlight the distinctiveness of the individual outcomes and the role they will play in the education of the civil engineer of the future.

For instance, ABET/EAC General Criteria outcome 3(a) states: "*Engineering programs must demonstrate that their students attain: (a) an ability to apply knowledge of mathematics, science, and engineering*"[3]. There are actually several topics wrapped up in this one outcome, and they all must be addressed in an ABET/EAC Self Study document, and they are all subject to the same level of expected achievement – "*an ability to apply knowledge of...*". This one ABET outcome is represented by BOK2 outcomes 1-Mathematics, 2-Natural Sciences, 5-Materials Science, and 6-Mechanics. This one ABET/EAC outcome expanded into four BOK2 outcomes for the sake of clarity and distinctiveness. The last topic in the ABET/EAC 3(a) is *engineering*, which is a nebulous term that lacks a clear-cut definition in this context, but is probably inherent in many of the other outcomes.

For reasons demonstrated by outcome 3(a) as noted above, one of the objectives of the BOK2Cmte was to clarify and coordinate the 15 outcomes of the BOK1 so that all users of the document would have the same understanding of what the civil engineering BOK really means. How this was accomplished is described in the following sections.

Identification of Outcomes

The first step for the BOK2Cmte was to identify topics that could be potential stand-alone outcomes. For this, the committee relied on potential topics from the BOK1, the NAE documents, comments from users of the BOK1, and the BOK's from other professions. In addition, members of BOK2Cmte had their own ideas of what should be included in the civil engineering BOK. The list of potential outcomes was in excess of 30 at the beginning. These include the disaggregation of the 15 outcomes from the BOK1. The 15 outcomes turned into about 25 potential new outcomes, although a precise number is not possible because of the redefinition of some of the outcomes.

"The committee focused on outcomes without consideration of courses, semesters, faculty expectations, co- and extra-curricular activities, access and delivery systems, and other administrative and logistical aspects of teaching and learning the outcomes. For example, topics listed in the outcomes could appear in more than one course, one course could contain many of the outcomes, and conceivably, one outcome could encompass an entire course."[2]

When the list of potential outcomes was condensed to 28 candidates, members of the committee, and some corresponding members, were subdivided into task committees to prepare, helpful, but not prescriptive, explanations for what the outcomes meant. For this, the committee solicited subject matter experts, as necessary, from the ranks of the corresponding members for some of the topics, such as History and Heritage, Risk and Uncertainty, Attitudes, and Sustainability. All of the explanations were limited to one page of text; the committee's thought being that if the candidate outcome was really worthy of being a stand-alone outcome, then one page of text should be sufficient to describe the meaning of an outcome to a reader of the document. These one page explanations kept the committee focused on the meaning of the outcome and became the "touchstone" when people wandered away from the true meaning of the outcome.

An example of an explanation is attached as Appendix B to this paper. The top section of the explanation presents an overview of the outcome. The bottom sections describe the levels of achievement appropriate for that particular outcome.

The explanations for all 24 outcomes are presented in Appendix J of Reference 2 and can be found at www.asce.org/raisethebar.

These explanations are an improvement over the discussion presented in the BOK1 because they are very carefully worded definitions of what is included, and not included, in any specific outcome. It was the committee's belief that these explanations will remove a substantial portion of the ambiguity inherent in the ABET/EAC outcomes and those of the BOK1.

Bloom's Taxonomy

In the General and Program Criteria of the four commissions of ABET (Engineering Accreditation Commission, Applied Science Accreditation Commission, Technology Accreditation Commission, and Computing Accreditation Commission) there are numerous terms used to represent the level of achievement expected to be achieved for the various outcomes, with no common definition for any of the terms that are used. Some of the terms used are: *an ability to apply knowledge of, an ability to function on, an understanding of, a recognition of, an ability to use, proficiency in, the capability to apply, an ability to conduct, etc.*[3]

As a result of the lack of definition and uniformity, it is difficult for the faculty in a specific department, or within the college, or for the members of a visiting ABET team, to understand or agree on what is expected of the students. This defect in nomenclature was recognized by the BOK1Cmte, and somewhat rectified for civil engineering in the BOK1.

Three levels of competence were recognized in the BOK1: Level 1 (Recognition), Level 2 (Understanding), and Level 3 (Ability). The use of these terms helped to clarify the problem, but trying to use them certainly pointed out the deficiencies in trying to adopt these terms as standardized terms. There was still too much ambiguity.

"Accordingly, the ASCE Levels of Achievement Subcommittee[9], which completed it work in September 2005, undertook a review of the educational psychology literature to find potential frameworks that might be applicable to the BOK. Specifically, the Subcommittee wanted a relatively simple framework, informed by educational research, which could link BOK outcomes to actual learning and achievement. The taxonomy that met simplicity and relevancy needs was Bloom's Taxonomy of the Cognitive Domain…"[10]. In addition, the chosen system would also have to be compatible with the ABET evaluation process, which means that assessability also was considered.

Based on this research and the recommendation from the Subcommittee, the BOK2Cmte decided to adopt Bloom's Taxonomy for the Cognitive Domain as the standard nomenclature for the BOK2. Appendix F in Reference 2 provides a succinct description of Bloom's Taxonomy of the Cognitive Domain. Appendix G of the same reference contains a companion article on the Affective Domain of Bloom's Taxonomy. The Affective Domain was not explicitly used in the BOK2, although there are outcomes where it may have some applicability, such as the Attitudes outcome.

By adopting Bloom's six levels of achievement, and the corresponding Bloom's verbs that are applicable to the respective levels of achievement, it became immediately possible to communicate within the BOK2Cmte and with users of the document, what was expected of the learner in terms of expected levels of achievement. The terms that were adopted to represent the six levels are as follows: Level 1-Knowledge, Level 2-Comprehension, Level 3-Application, Level 4-Analysis, Level 5-Synthesis, and Level 6-Evaluation.

For each outcome, a rubric was developed that contained a short statement for each of the six levels of achievement, with each of the six statements incorporating an appropriate Bloom's verb.

For instance, for the Sustainability outcome, the six statements are as follows: (condensed with the Bloom's verb bolded)

Level 1: **Define** key aspects of sustainability…
Level 2: **Explain** key properties of sustainability…
Level 3: **Apply** the principles of sustainability…
Level 4: **Analyze** systems of engineered works…for sustainable performance
Level 5: **Design** a complex system, process or project to perform sustainably. **Develop** new, more sustainable technology. **Create** new knowledge…
Level 6: **Evaluate** the sustainability…

As can be seen, the progression from Level 1 through Level 6 provides for increasing complexity and increasing knowledge of the subject. Also the combination of the Levels and the usage of the Bloom's verbs is intuitively easy to grasp and readily adaptable to all 24 of the BOK2 outcomes.

The rubrics for each of the 24 outcomes are presented in Appendix I of Reference 2. A tabular listing of all 24 outcomes is presented in Appendix D of this report.

The BOK2Cmte is convinced that application of this system would improve the ABET General and Program Criteria. It would improve communication and understanding between faculty members teaching sequential classes, or service classes, between departments within a college, and amongst and between the ABET visiting team members and the faculty of the program being reviewed. This shift to a standard nomenclature would entail some additional work for the member societies of ABET to rewrite their program criteria. ASCE has already done exactly that and the time and effort required to accomplish this was relatively minor, considering the tremendous difference between the "old" text and the "new" text. In addition, the ABET/EAC General Criteria were restated using Bloom's Taxonomy as an exercise by an ASCE member, and the resulting Criteria were much more readable and easier to understand.

After the statements for each of the Bloom's levels were accepted for each of the 24 outcomes, then it was time to decide what level of achievement was the lower bound for entry into the professional practice of civil engineering for each outcome.

Setting Levels of Achievement

Not every outcome of the BOK2 requires the same level of achievement as all of the others. For instance, most practicing civil engineers can get by quite nicely with Level 3-Application for the Mathematics outcome. However, for Design, which may be considered the heart and soul of civil engineering, greater capabilities are needed and expected. Hence, the Level 6-Evaluation for the Design outcome.

The chart in Appendix B of this paper lists the 24 outcomes and their respective levels of achievement. Each of these levels of achievement for each of the outcomes was thoroughly deliberated within the overall committee, including the corresponding members. Completion of the respective levels of achievement for each outcome will be required for the civil engineer of the future to enter the professional practice of civil engineering. These go beyond graduation requirements from a baccalaureate or master's program, in that fulfillment of almost two-thirds of the outcomes rely, in part, on prelicensure experience.

In the Appendix B chart, it can be seen that no outcome has a level of achievement less than Level 3-Application. Similarly, only three outcomes have their levels of achievement set at Level 6-Evaluation. These are No. 9-Design, No. 15-Technical Specialization, and No. 24-Professional and Ethical Responsibility.

Much of our deliberation on the levels of achievement revolved around what do we expect out of our baccalaureate students now, and what should be expected in the future for entry into the profession. Although use of the six levels of achievement and the Bloom's terminology was new to most committee members, the system is so intuitive that, for the most part, consensus on setting the respective levels of achievement was readily achieved.

There have certainly differences of opinion during the discussions on how and when the specified levels of achievement should be achieved. It is clear that it is practically impossible to push more content into the 120 to 128 semester hour baccalaureate program. If something is added to the curriculum, then something else must get pushed out. This conundrum was the focus of the next step for the BOK2Cmte .

When are the Levels of Achievement Achieved?

In the chart in Appendix B, each of the cells under the levels of achievement is filled with either a "B", an "M/30", or an "E". The furthest cell to the right for each outcome is the level of achievement that is required for the civil engineer of the future to enter the professional practice of civil engineering. But when is this to be achieved other than prior to professional licensure? The letters in the cells tell the user of the chart when this is to be achieved and the responsibility for ensuring the achievement. Actually, the fledgling engineer is the person responsible for ensuring achievement, but there are many entities that will be assisting the engineer in achieving these outcomes.

The process the BOK2Cmte used to set the various levels of achievement was as follows:

1. The committee first determined what level of achievement was necessary in each outcome for the civil engineer of the future to enter the professional practice of civil engineering. There was much give and take in these deliberations. Because over 50 experienced civil engineers participated in these deliberations, consensus was achieved without ever having to resort to a vote of the participants.

2. After this "professional practice" line was set, the committee then determined what level of achievement was proper at the time of graduation from an undergraduate civil engineering program. Again, consensus was reached without having to vote, largely as a result of the preparatory work done by the committee in developing the explanations and the rubrics.

3. Next, the division of responsibility between the post-baccalaureate education (M/30) and the pre-licensure professional experience was decided upon. Through the committee's discussions, it became apparent that some levels of achievement in some of the outcomes were better achieved in a structured educational format than while working as a not-yet licensed engineer. And vice-versa. Again, with a clear understanding of what was to be achieved based on the rubrics and the explanations, the allocation of the remaining cells between M/30 and E was decided upon in a collegial manner without having to resort to a formal vote.

A "B" in a cell indicates that *"Portion of the BOK fulfilled through the bachelor's degree"*[2]. It is apparent that most of the cells are filled with B's. At first glance, this would seem to indicate that a tremendous percentage of the total BOK must be acquired in the undergraduate program. This is true, and not much different from today's situation. The BSCE has been treated as a defacto terminal degree for practice for over 100 years. However, there are no B's under Level 6, and only one in Level 5, that being Design. All of the other outcomes have their highest B's in either Level 2, Level 3, or Level 4. The BOK2Cmte realized that not much more content, if any, could be squeezed into the bachelor's degree programs. Therefore, the distribution of B's reflects very closely the curriculum content of the typical undergraduate civil engineering program of today, with some enrichment with new or clarified content.

Assuming this is all true, then where is the "Raise the Bar" content that PS-465 is built upon?

That is where the other letters in the cells come in. An "M/30" in a cell indicates that *"Portion of the BOK fulfilled through the master's degree or equivalent (approximately 30 semester credit hours of acceptable graduate-level or upper-level undergraduate courses in a specialized technical area and/or professional practice area related to civil engineering)"*[2]. An "E" in a cell indicates that *"Portion of the BOK fulfilled through the prelicensure experience"*[2].

These E and M/30 cells indicate achievement of outcomes that generally cannot and generally should not be part of the undergraduate curriculum. These constitute the major portion of the "Raise the Bar" effort. The M/30 is easy to understand. These knowledge, skills and attitudes associated with the individual outcomes will be achieved in either a formal education, post-baccalaureate degree program, such as an MSCE or an MEng program, or a carefully selected collection of coordinated classes in a specialized field that do not necessarily culminate in a degree granted by a university or a college. Large consulting, industrial, and construction firms, as well as the armed services, have in-house educational service providers that may be able to provide the necessary coursework to fulfill these requirements.

The third letter, the "E", is revolutionary in that the employers of the pre-licensure engineers are being put on notice that they have a responsibility to the young engineers in their charge to help them get ready for licensure. Many employers of young engineers already take this for granted, and they do an admirable job of preparing their young engineers. But the BOK2 makes this responsibility explicit. This division of responsibility is perhaps best illustrated by outcome No. 15-Technical Specialization.

The first level of achievement (Knowledge) for this outcome is designated as a "B". This indicates that the faculty will introduce technical specialization to the students at some time in the undergraduate program. As outcome No. 14 shows, in the undergraduate program the students are being exposed to the breadth of civil engineering sub-disciplines, but at some point, the faculty would let the students know that they can specialize in any of the sub-disciplines. Also, they may want to specialize in a field related to civil engineering, such as Structural Health Monitoring of the Infrastructure, which would require coursework outside of civil engineering, probably in electrical engineering. But that is as far as this outcome would go at the undergraduate level.

Achievement levels 2, 3, 4 and 5 are designated as "M/30". This is easiest to visualize in a traditional MSCE program. As the graduate student makes his/her way through the master's program, they become more proficient in their chosen technical specialization. However, when they receive their MSCE, they still have a lot to learn. This is where the employer comes in, the "E". Until the young engineer has actually worked in a design firm, or for a contractor, or a governmental agency in their selected field, they have really not achieved the Level 6-Evaluation status. This is reflected in the licensing laws and regulations of the states and territories of the United States. All of the jurisdictions require a period of work experience before the candidate can become a licensed professional engineer.

In a similar manner for the other outcomes that have an "E" in their furthest right cell, the employer has a responsibility for the educational development of the young engineer.

There is a lot of information and guidance in the chart in Appendix B. This chart is the roadmap for successful achievement of the BOK2.

The Coordinated Final Document

When all of the rubrics and explanation sheets were completed, the BOK2Cmte stood back and asked – "Does all of this make sense?" "Are there duplications, redundancies, or extraneous material that is not needed?" "Can some of the outcomes be combined and still not lose content or distinctiveness?"

Based on this introspective evaluation, 28 outcomes turned into 24 for the final document. Early on in the life of the committee, assignments were made where committee members were assigned to be "champions" for each of the topics (potential outcomes). As a result, these champions fought very hard for their outcomes and the designation as a stand-alone outcome throughout the life of the committee. However, in the end, a consensus was reached based on the documentation that these 24 outcomes sufficiently defined the Body of Knowledge for Civil Engineering.

Conclusions

The Second Edition of the Body of Knowledge for Civil Engineering is a comprehensive document that is expected to set the educational stage for achievement of the Vision for Civil Engineering in 2025. The BOK2 has many improvements over the BOK1, including:

- The use of Bloom's Taxonomy for the Cognitive Domain in defining the levels of achievement for the 24 outcomes,
- An explanation document for each outcome that defines what is included in that outcome,
- A rubric for each outcome that defines each level of achievement,
- A system that designates when in the pre-licensure educational and work experience of a young engineer, each level of achievement for each outcome is attained, and
- The specification of an employer's responsibility in the development of the young engineer.

It is the belief of the BOK2Cmte that the BOK2 will be an enduring document, but that it will become outdated in time due to the changing nature of our profession. However, it is also the strong belief of the committee that the outcome rubrics and explanation sheets are the heart and soul of the BOK2 and implementation of the contents of the report will help "Raise the Bar" and position civil engineers to be technological leaders in developing a sustainable world.

REFERENCES

1. ASCE Body of Knowledge Committee of the Task Committee on Academic Prerequisites for Professional Practice. (2004). Civil Engineering Body of Knowledge for the 21st Century, January 12. (http://www.asce.org/raisethebar)
2. ASCE Body of Knowledge Committee of the Task Committee on Academic Prerequisites for Professional Practice. (2008). Second Edition of Civil Engineering Body of Knowledge for the 21st Century, January. (http://www.asce.org/raisethebar)
3. ABET, Inc. Criteria for Accrediting Engineering Programs. 2007-2008 Evaluation Cycle. Baltimore, MD. (http://www.abet.org)
4. NAE (National Academy of Engineering). (2004). The Engineer of 2020: Visions of Engineering in the New Century. Washington, D.C., The National Academies Press.
5. NAE (National Academy of Engineering). (2005). Educating the Engineer of 2020: Adapting Engineering Education to the New Century. Washington, D.C., The National Academies Press.
6. National Academy of Sciences, National Academy of Engineering, and Institute of Medicine of the National Academies. (2006) Rising Above the Gathering Storm – Energizing and Employing America for a Brighter Economic Future. Washington D. C., The National Academies Press.
7. ASCE Steering Committee to Plan a Summit on the Future of the Civil Engineering Profession in 2025 (2007). Vision for Civil Engineering in 2025, (http://www.asce.org/raisethebar)
8. McMasters, John H. Boeing Involvement with ABET – An Historical Overview. Internal document of the Boeing Corporation, July 8, 1999.
9. ASCE Levels of Achievement Subcommittee. 2005. Levels of Achievement Applicable to the Body of Knowledge Required for Entry Into the Practice of Civil Engineering at the Professional Level. Reston, VA, September. (http://www.asce.org/raisethebar)
10. 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. David McKay, New York, NY.

Appendix A: Relationship of ABET, BOK1 and BOK2 Outcomes

(Note: General relationships are presented, not one-to-one mapping)

ABET Outcome Titles[a]	BOK1 Outcome Titles[b]	BOK2 Outcome Titles[c]
(a) Mathematics, science, engineering	1. Technical core	1. Mathematics 2. Natural sciences 5. Materials science 6. Mechanics
(b) Experiments	2. Experiments	7. Experiments
(c) Design	3. Design	9. Design 10. Sustainability
	3. Design	12. Risk/uncertainty
(d) Multidisciplinary teams	4. Multi-disciplinary teams	21. Teamwork
(e) Engineering problems	5. Engineering problems	8. Problem recognition and solving
(f) Professional and ethical responsibility	6. Professional and ethical responsibility	24. Professional and ethical responsibility
(g) Communication	7. Communication	16. Communication
(h) Impact of engineering	8. Impact of engineering	11. Contemporary issues and historical perspectives
(i) Life-long learning	9. Life-long learning	23. Life-long learning
(j) Contemporary issues	10. Contemporary issues	11. Contemporary issues and historical perspectives 19. Globalization
(k) Engineering tools	11. Engineering tools	8. Problem recognition and solving
	12. Specialized area related to civil engineering	15. Technical specialization
Civil engineering EAC Program Criteria	13. Project management, construction, and asset management	13. Project management
	14. Business and public policy	17. Public policy 18. Business and public administration
Civil engineering EAC Program Criteria	15. Leadership	20. Leadership 22. Attitudes
ABET/EAC Criterion 4[d]	ABET/EAC Criterion 4[d]	3. Humanities 4. Social sciences
Civil engineering EAC Program Criteria	Civil engineering EAC Program Criteria	14. Breadth in civil engineering areas

a) Short names
b) Short names of outcomes appearing in the BOK1 report,[1] pp. 24-29
c) Short names from BOK2 report, Table 1, page 16
d) General education component

Appendix B: Example of an Outcome Explanation

Outcome 15: Technical Specialization
Overview: Advanced technical knowledge and skills beyond that included in the traditional four-year bachelor's degree are essential to attaining the BOK necessary for entry into the professional practice of civil engineering. Advanced technical specialization includes all traditionally defined areas of civil engineering practice, but also includes coherent combinations of these traditional areas—that is, advanced knowledge and skills in the area of general civil engineering are appropriate within the context of advanced specialization. Civil engineering specializations in nontraditional, boundary, or such emerging fields as ecological engineering and nanotechnology are suitable and encouraged. Many non-engineering degrees and courses have content that would be beneficial to the professional practice of civil engineering. These topics/courses may be combined with other appropriate coursework to fulfill the technical specialization and/or other outcomes through the M/30. However, such non-engineering degrees as the M.B.A., J.D., and M.D. would most likely not, by themselves, fulfill the technical specialization of the BOK.
B: ***Define* key aspects of advanced technical specialization appropriate to civil engineering. (L1)** Before one can specialize one must have a basic level of knowledge about advanced technical specialization—that is, an individual must know what is expected of civil engineers that specialize in a particular area. This level of knowledge may be attained through traditional courses as well as through guest lectures by practitioners who practice in the area of interest.
M/30: *Design* a complex system or process or *create* new knowledge or technologies in a traditional or emerging advanced specialized technical area appropriate to civil engineering. (L5) In recognition of the ever-advancing profession of civil engineering, advanced technical specialization areas appropriate to civil engineering are, by necessity, open and encompassing of the future needs of our profession. Additionally, discovery and creation of new technologies and knowledge are equally important to the profession's future. Regardless of the specific path towards attainment of technical specialization, tangible relation to the professional practice of civil engineering is required. Individuals are expected to, within their technical area of specialization, synthesize a design, research and develop new methods or tools, and/or discover or create new knowledge or technologies.
E: *Evaluate* the design of a complex system or process, or *evaluate* the validity of newly created knowledge or technologies in a traditional or emerging advanced specialized technical area appropriate to civil engineering. (L6) The prelicensure experience should include opportunities to practice—under appropriate guidance and mentorship—civil engineering within the technical area of specialization. The role of practitioner mentorship and review is critical in terms of validating the individual's ability to evaluate, compare and contrast, and validate multiple options within the specific advanced technical area of specialization.

Appendix C: The 24 Outcome Titles and Their Respective Levels of Achievement

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 & Historical 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 in a specialized technical area and/or professional practice area related to civil engineering)
E	Portion of the BOK fulfilled through the pre-licensure experience

Appendix D: The 24 Outcomes

Entry into the practice of civil engineering at the professional level requires fulfilling 24 outcomes to the various levels of achievement.

Key: L1 through **L6** refers to these levels of achievement:

Level 1 **(L1)** - Knowledge
Level 2 **(L2)** - Comprehension
Level 3 **(L3)** - Application
Level 4 **(L4)** - Analysis
Level 5 **(L5)** - Synthesis
Level 6 **(L6)** - Evaluation

Outcome number and title	To enter the practice of civil engineering at the professional level, an individual must be able to demonstrate this level of achievement
Foundational Outcomes	
1 Mathematics	***Solve*** problems in mathematics through differential equations and ***apply*** this knowledge to the solution of engineering problems. **(L3)**
2 Natural Sciences	***Solve*** problems in calculus-based physics, chemistry, and one additional area of natural science and ***apply*** this knowledge to the solution of engineering problems. **(L3)**
3 Humanities	***Demonstrate*** the importance of the humanities in the professional practice of engineering **(L3)**
4 Social Sciences	***Demonstrate*** the incorporation of social sciences knowledge into the professional practice of engineering. **(L3)**
Technical Outcomes	
5 Materials Science	**Use** knowledge of materials science to ***solve*** problems appropriate to civil engineering. **(L3)**
6 Mechanics	**Analyze** and solve problems in solid and fluid mechanics. **(L4)**
7 Experiments	***Specify*** an experiment to meet a need, conduct the experiment, and analyze and ***explain*** the resulting data. **(L5)**
8 Problem Recognition and Solving	***Formulate*** and solve an ill-defined engineering problem appropriate to civil engineering by ***selecting*** and applying appropriate techniques and tools. **(L4)**
9 Design	***Evaluate*** the design of a complex system, component, or process and ***assess*** compliance with customary standards of practice, user's and project's needs, and relevant constraints. **(L6)**
10 Sustainability	***Analyze*** systems of engineered works, whether traditional or emergent, for sustainable performance. **(L4)**

11 Contemporary Issues and Historical Perspectives	***Analyze*, *compare,*** and ***contrast*** the economic, environmental, political, and societal impacts of engineering. **(L4)**
12 Risk and Uncertainty	***Analyze*** the loading and capacity, and the effects of their respective uncertainties, for a well-defined design and ***illustrate*** the underlying probability of failure (or non-performance) for a specified failure mode. **(L4)**
13 Project Management	***Formulate*** documents to be incorporated into the project management plan. **(L4)**
14 Breadth in Civil Engineering Areas	***Analyze*** and solve well-defined engineering problems in at least four technical areas appropriate to civil engineering. **(L4)**
15 Technical Specialization	***Evaluate*** the design of a complex system or process, or ***evaluate*** the validity of newly-created knowledge or technologies in a traditional or emerging advanced specialized technical area appropriate to civil engineering. **(L6)**
Professional Outcomes	
16 Communication	***Plan, compose,*** and ***integrate*** the verbal, written, virtual, and graphical communication of a project to technical and non-technical audiences. **(L5)**
17 Public Policy	***Apply*** public policy process techniques to simple public policy problems related to civil engineering works. **(L3)**
18 Business and Public Administration	***Apply*** business and public administration concepts and processes. **(L3)**
19 Globalization	***Analyze*** engineering works and services delivered in a global context. **(L4)**
20 Leadership	***Organize*** and ***direct*** the efforts of a group. **(L4)**
21 Teamwork	***Function*** effectively as a member of a multi-disciplinary team. **(L4)**
22 Attitudes	***Demonstrate*** attitudes supportive of the professional practice of civil engineering. **(L3)**
23 Life-Long Learning	***Plan*** and ***execute*** the acquisition of required expertise appropriate for professional practice. **(L5)**
24 Professional and Ethical Responsibility	***Justify*** a solution to an engineering problem based on professional and ethical standards and ***assess*** personal professional and ethical development. **(L6)**

Chapter 5

Revising Accreditation Criteria

Stephen J. Ressler, P.E., Ph.D., Dist.M.ASCE, *U.S. Military Academy*

The Raise the Bar Initiative: Charting the Future by Understanding the Path to the Present – Accreditation Criteria

Background

At the 1995 American Society of Civil Engineers (ASCE) Civil Engineering Education Conference (CEEC '95), key leaders from industry and academia identified four primary issue areas requiring the focused attention of the U.S. civil engineering community:

- faculty development,
- integration of the civil engineering curriculum,
- practitioner involvement in education, and
- the professional degree.[1]

The fourth of these issue areas—the professional degree—reflected a growing consensus that the traditional four-year baccalaureate degree was becoming increasingly inadequate as formal academic preparation for the professional practice of civil engineering. In October 1998, the call for action issued at the CEEC '95 resulted in the passage of ASCE Policy Statement 465—Academic Prerequisites for Licensure and Professional Practice. The initial version of this policy stated that the Society "supports the concept of the master's degree as the First Professional Degree for the practice of civil engineering at the professional level."[2]

In 2002, an ASCE Board-level committee, the Committee on Academic Prerequisites for Professional Practice (CAP[3]), was formed to guide the implementation of Policy Statement 465—dubbed the "Raise the Bar" initiative. In the succeeding decade, the initiative has made substantial progress in five distinctly different but interrelated domains—establishing a formalized civil engineering body of knowledge, developing revised accreditation criteria, fostering curriculum reform, formulating experiential guidelines, and modifying licensure laws and rules.[3]

Today, the Raise the Bar initiative is in transition. Several key leaders of CAP[3] are moving to new roles, even as ASCE is working to integrate Policy Statement 465 implementation into the Society's broader strategic planning process. At this important juncture, there is a critical need to document the achievements of the past, discern key lessons learned, and chart an appropriate course for the future.

Purpose

The purposes of this paper are (1) to summarize the decade-long process of developing and implementing new accreditation criteria in support of the ASCE Raise the Bar initiative; (2) to identify the principal lessons learned through this process; and (3) to provide recommendations for future developments in the accreditation domain of this ongoing effort to raise the educational standard for civil engineering professional practice.

The Civil Engineering Body of Knowledge

Soon after its establishment in 2002, CAP[3] determined that the initial focus of Policy Statement 465 on the master's degree was misplaced. Considering the general characteristics of an ideal profession, the committee came to recognize that the specification of academic degree requirements should follow from a more fundamental analysis of the profession's body of knowledge (BOK). Consistent with this insight, CAP[3] initiated a broad-based effort to formally define the Civil Engineering BOK. In January 2004 this endeavor achieved a major milestone with ASCE's publication of *Civil Engineering Body of Knowledge for the 21st Century*—a report describing the knowledge, skills, and attitudes necessary for entry into the practice of civil engineering at the professional level.[4] This report introduced a conceptual framework that has proved to be enormously valuable in guiding the subsequent implementation of Policy Statement 465. The conceptual framework includes three key characteristics:

- The Civil Engineering BOK is defined in terms of *outcomes*.
- The outcomes have clearly defined *levels of achievement*.
- Expected levels of achievement are separately specified for baccalaureate-level education, master's-level education, and pre-licensure experience.

This first edition of the Civil Engineering BOK (commonly abbreviated BOK1) defined 15 outcomes, the first eleven of which nominally corresponded to Criterion 3(a)-(k) of the ABET Criteria for Accrediting Engineering Programs.[5] The inclusion of four BOK outcomes *beyond* the eleven of ABET Criterion 3 suggested that the BOK could not be adequately addressed in the traditional four-year baccalaureate degree program—a conclusion subsequently affirmed by a comprehensive curriculum analysis.[6]

In October 2004, the ASCE Board reinforced the importance of the BOK by modifying the wording of Policy Statement 465 as follows:

> The American Society of Civil Engineers supports the attainment of a Body of Knowledge for entry into the practice of civil engineering at the professional level. This would be accomplished through the adoption of appropriate engineering education and experience requirements as a prerequisite for licensure.[7]

Translating the BOK to Accreditation Criteria

With the Civil Engineering BOK formally defined and endorsed in ASCE policy, a broad-based effort to develop and implement new BOK1-compliant ABET accreditation criteria began immediately. The CAP[3] Accreditation Committee was established and charged with leading this effort in January 2004.

Implicit in the committee's work was an underlying assumption that the ABET accreditation process is an appropriate mechanism for fostering a transition toward BOK1-compliant curricula in ABET-accredited civil engineering programs. This assumption is well founded. "Engineering Change," a study conducted by the Penn State Center for the Study of Higher Education, clearly demonstrates that accreditation criteria can provide a powerful stimulus for curricular reform.[8] And once curricular reform is underway, the accreditation process provides an effective quality control mechanism to ensure that changes are being implemented in accordance with desired ends.

Given this linkage between accreditation and curricular reform, CAP[3] has proposed that civil engineers should be able to fulfill the Civil Engineering BOK by following either of two alternative paths—each of which includes at least one ABET-accredited degree. The two paths are as follows:

- **B^{ABET} + $(M/30)^{Validated}$ & E** – This is currently considered to be the primary path for BOK fulfillment. "B^{ABET}" refers to a civil engineering baccalaureate degree accredited by the Engineering Accreditation Commission (EAC) of ABET. "M/30" refers to a master's degree or approximately 30 semester credits of acceptable graduate-level or upper-level undergraduate courses in a technical or professional practice area related to civil engineering. "E" refers to engineering experience. For this path, the accreditation process provides validation of the baccalaureate component of the BOK. Validation of the "M/30" program will be provided by an approved outside entity, which might also be ABET.

- **B + M^{ABET} & E** – This alternate path is being considered by ASCE to allow for greater flexibility in BOK fulfillment. For this path, the baccalaureate degree need not be an ABET EAC-accredited civil engineering degree. Rather, validation of the baccalaureate and master's-level components of the BOK is accomplished through ABET EAC-accreditation of the civil engineering master's degree.

A detailed discussion of this "two-path model" is beyond the scope of this paper. However, in the specific context of accreditation criteria development, three key characteristics of the model must be emphasized:

- ABET accreditation is essential to the validation of BOK fulfillment on *both paths*.
- The two-path model is only feasible if ABET EAC accreditation is possible at *both* the baccalaureate level and the master's level.
- Master's-level accreditation must validate the attainment of baccalaureate-level BOK outcomes as well as masters-level BOK outcomes.

Although the ABET criteria have been shown to constitute a viable instrument for facilitating BOK fulfillment, it is *not* true that these criteria are fully adaptable to this purpose. The ABET EAC criteria consist of three different components, each with its own unique limitations as an instrument for BOK fulfillment:

- The ***General Criteria for Baccalaureate Level Programs (GCBLP)*** are applicable to *all* ABET EAC-accredited programs in *all* engineering disciplines. Changing these criteria would require the support of ABET and its 29 member societies. The ABET Engineering Accreditation Commission (EAC) is currently considering the establishment of a process for reviewing and updating the GCBLP;[9] however, that process is unlikely to be implemented in the short term, and ASCE's influence over it will necessarily be somewhat limited.

- The ***General Criteria for Masters Level Programs (GCMLP)*** are also applicable to all engineering disciplines; however, because very few programs are currently accredited at the master's level, it has been possible for ASCE to influence changes to these criteria. In general, however, such changes must still be applicable and acceptable to all engineering disciplines. Discipline-specific additions to the GCMLP would not be permissible.

- The ***Program Criteria*** are applicable only to specific engineering disciplines and are established and maintained by the associated ABET member societies. The ***Civil Engineering Program Criteria (CEPC)*** are applicable to "civil and similarly named engineering programs." As Lead Society for the civil engineering curricular area, ASCE has responsibility for developing and maintaining the CEPC. Because ASCE has considerable authority to change these criteria, the CEPC must necessarily be the principal accreditation-related mechanism for BOK implementation. Nonetheless, ASCE is not able to exercise complete control over these criteria. All engineering program criteria are subject to approval by the EAC and the ABET Board of Directors; and in order to gain approval, proposed criteria can address only curricular content and faculty qualifications, and they must not be overly prescriptive. In an era when new engineering disciplines are constantly emerging and existing disciplinary boundaries are blurring, program criteria are viewed as anachronistic in some ABET circles. In this environment, ASCE's ability to use the CEPC as its principal instrument for implementing curricular reform is significantly constrained.

Another major challenge in the use of ABET criteria as a mechanism for BOK implementation lies in a fundamental difference between the nature of the BOK and the nature of accreditation criteria. Although it was not intended as such, the BOK has many characteristics of a strategic vision. It represents, by its very nature, an ambitious, comprehensive, future-oriented goal—one to which all civil engineering programs should aspire, but one that few programs will ever achieve in all of its aspects. Conversely, accreditation criteria represent only a *minimum standard* of educational attainment. They are grounded firmly in the present; they tend to be narrow in scope; and they must be *reasonably attainable by all programs*.

The CAP^3 Accreditation Committee addressed this challenge by adopting the following approach to the formulation of BOK-compliant criteria:

- The criteria should not conflict with the BOK outcomes.
- Each BOK outcome should map to at least one readily identifiable criterion (or portion of a criterion).
- Each of these criteria should communicate an appropriate *direction* toward attainment of the associated BOK outcome. Taken as a whole, however, the criteria should stop short of prescribing full BOK attainment, because doing so would be overly prescriptive.

This approach is illustrated graphically in Figure 1 below. As indicated in this graphic, the accreditation criteria represent only a small subset of the BOK; yet there is a clear one-to-one mapping from BOK outcomes to criteria provisions.

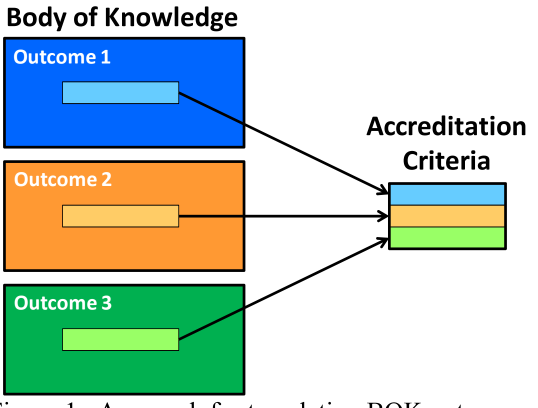


Figure 1. Approach for translating BOK outcomes to accreditation criteria provisions.

This approach evolved during a collaborative two-year process of study, deliberation, and critical review, and culminated in the submission of proposed new BOK1-compliant accreditation criteria (both GCMLP and CEPC) to the ABET EAC in June 2006. These criteria, provided in Appendix A, achieved final approval by the ABET Board of Directors in October 2007 and were implemented for accreditation visits starting in the fall of 2008. Given the six-year ABET accreditation cycle, all U.S. civil engineering programs will have been evaluated under these BOK1-compliant criteria by Academic Year 2013-14.

In conjunction with developing these new criteria, the CAP^3 Accreditation Committee recognized the need to provide supplemental written guidance for civil engineering department heads and ABET Program Evaluators. This guidance was intended to serve two specific purposes:

- Provide a scholarly *rationale* for each provision of the new criteria vis-à-vis the Civil Engineering BOK, by articulating the mapping from BOK outcomes to criteria provisions.
- Provide specific operational guidelines on criteria compliance.

The CAP^3 Accreditation Committee fulfilled both of these purposes through the publication of an extensive ASCE Commentary.[10]

Appendix B shows the mapping between BOK outcomes and specific provisions of the BOK1-compliant accreditation criteria, in tabular format. In successive columns, this table lists the fifteen BOK1 outcomes, the specific requirements articulated for each outcome in *Civil Engineering Body of Knowledge for the 21st Century*, and the associated provisions of the ABET GCBLP, GCMLP, and CEPC. In general terms, the mapping is as follows:

- Outcomes 1 through 11 map directly to Criterion 3(a)-(k) of the GCBLP.
- Additional requirements associated with Outcomes 1, 2, 3, and 6 correspond to supplemental provisions in the CEPC.
- Outcome 12 (advanced-level specialization) maps to the GCMLP.
- Outcomes 13 through 15 (the professional practice outcomes) map to the CEPC.

Appendix B also illustrates the approach used by the CAP^3 Accreditation Committee to formulate BOK1-compliant accreditation criteria, as discussed above. An outcome-by-outcome comparison clearly demonstrates that the BOK outcomes represent a significantly more ambitious and comprehensive standard than do the ABET criteria. For example, consider BOK Outcome 1, which includes explicit requirements for "biology, chemistry, ecology, geology/geomorphology, engineering economics, mechanics, material properties, systems, geo-spatial representation, and information technology." The corresponding provision of the CEPC requires only "one additional area of basic science, consistent with the program educational objectives."

The sharp difference between the BOK outcomes and the criteria is entirely appropriate, as it reflects the distinctly different natures of these two documents. If the criteria were written at the same level of detail as the BOK, they would be overly prescriptive and perhaps unattainable. If the BOK were formulated as a minimum standard, it would fail to serve as an aspirational goal. The difference suggests, however, that the translation of BOK outcomes to accreditation criteria will always be an inherently challenging process.

Removing the Prohibition on Dual-Level Accreditation

In 2004, as the development of BOK1-compliant accreditation criteria was just getting underway, the CAP^3 Accreditation Committee encountered another significant constraint in the ABET accreditation system—the prohibition on dual-level accreditation. This long-standing ABET policy specified that engineering programs at a given institution could seek EAC accreditation at *either* the baccalaureate level *or* the master's level, *but not both*. From ASCE's perspective, the prohibition on dual-level accreditation was problematic, because it effectively eliminated the alternate path to BOK fulfillment, $\mathbf{B + M^{ABET}}$ **& E**, as described above.

In early 2005, CAP^3 responded to this challenge by formally requesting, in writing, that ABET modify its *Policies and Procedures Manual* to eliminate the prohibition. ABET referred ASCE's request to the Engineering Deans Council for comment; and in June 2005, the deans responded by passing a resolution opposing any change to the policy.[11] Their principal points of opposition were as follows:

- Many states mandate accreditation of all programs for which accreditation is available; thus, if the prohibition were lifted, master-level accreditation would become mandatory.
- If the prohibition were lifted, market forces would dictate that both baccalaureate and master's programs be accredited.
- Discipline-specific accreditation at the master's level would discourage and put undesirable restrictions on interdisciplinary breadth.
- Masters-level accreditation would restrict opportunities for admission of international graduate students and students with non-engineering undergraduate degrees.

In turn, ASCE responded with a communications campaign aimed at articulating the benefits of removing the prohibition, while addressing the deans' key points of opposition. For example, after an extensive search, ASCE was unable to identify any states that mandate accreditation of all programs for which accreditation is available. And ASCE was able to demonstrate that international students and students with non-engineering undergraduate degrees would actually *benefit* from dual-level accreditation, because broader availability of accredited master's degree programs would greatly simplify their path to professional licensure in the U.S.

In response to the deans' opposition, CAP[3] members prepared white papers and wrote articles in ASEE *Prism* magazine, *PE* magazine (National Society of Professional Engineers), and the *Proceedings of the 2006 ASEE Annual Conference*.[12, 13,14] This campaign also gained considerable credibility from the National Academy of Engineering (NAE) *Educating the Engineer of 2020* report, which explicitly recommended removal of the prohibition on dual-level accreditation.[15] Ultimately, after an intensive ASCE lobbying effort, the ABET Board of Directors voted to remove the prohibition in March 2008, and the *ABET Policies and Procedures Manual* was amended accordingly. As a result of this policy change and the implementation of new master's-level accreditation criteria (GCMLP), effective in the fall of 2008, the alternate path (**B + M$^{\mathbf{ABET}}$ & E)** has become a viable route to BOK attainment—though not yet to professional licensure.

The Evolving BOK

While the formulation of new BOK1-compliant accreditation criteria was still in progress, it became apparent that significant updates to BOK1 itself would be required. These revisions were driven by:

- aspects of the 1st Edition that did not lend themselves to effective measurement and assessment;

- publication of several strategic vision documents that called for future engineers to develop certain knowledge, skills, and attitudes that had *not* been included in BOK1;[16,17] and

- continuing changes in the global civil engineering professional environment (e.g., a dramatic increase in the importance of sustainability and green technologies).

As a result, a second edition of the Civil Engineering BOK was initiated in October 2005 and published in February 2008. The *Civil Engineering Body of Knowledge for the 21st Century, Second Edition,* (abbreviated BOK2) incorporates two particularly substantive changes from the first edition:[18]

- The number of outcomes was increased from 15 to 24. To some extent, this increase reflects the BOK2 authors' attempt to enhance clarity and specificity, rather than to increase the scope of the BOK. Nonetheless, the BOK2 Outcomes do place increased emphasis on such topics as the natural sciences, the humanities, sustainability, globalization, risk and uncertainty, and public policy.

- The BOK2 uses Bloom's Taxonomy as the basis for defining levels of achievement.[19] The fundamental premise of Bloom's Taxonomy is that an educational objective can be referenced to a specific level of cognitive development through the verb used in the objective statement. Table 1 shows Bloom's six levels of cognitive development, accompanied by illustrative examples of verbs associated with each level. The use of measurable, action-oriented verbs linked to levels of achievement is beneficial, in that the resulting outcome statements can be assessed more effectively and consistently.

Level		Illustrative Verbs
1	Knowledge	define, identify, label, list,
2	Comprehension	classify, describe, explain, generalize, paraphrase
3	Application	apply, calculate, compute, demonstrate, solve
4	Analysis	analyze, differentiate, formulate, organize, prioritize
5	Synthesis	create, design, develop, devise, integrate, plan
6	Evaluation	critique, evaluate, judge, justify

Table 1. Six levels of cognitive development and illustrative verbs, as defined in Bloom's Taxonomy

A complete list of the 24 BOK2 Outcomes is provided in Appendix C, along with the expected level of achievement for each one. Note that the outcomes are organized into three broad categories—foundational, technical, and professional. Note also that separate levels of achievement are defined for the bachelor's degree, for the master's degree (or equivalent), and for pre-licensure experience. Following the framework established by the BOK1, this structure emphasizes that both education and experience are essential for full attainment of the Civil Engineering BOK. A formal comparison of these outcomes with the BOK1-compliant accreditation criteria strongly suggests that the criteria will need to be further modified to foster BOK2 implementation.[20]

Although CAP[3] has not yet initiated the development of BOK2-compliant accreditation criteria, it has formed two committees to study and formulate guidelines for the fulfillment of the Civil Engineering BOK:

- The BOK Educational Fulfillment Committee was formed in 2007. Composed of representatives of ten widely varying institutions, this committee investigated the incorporation of the 24 BOK2 outcomes into civil engineering curricula.

- The BOK Experiential Fulfillment Committee was formed in early 2009 to address those BOK2 outcomes requiring pre-licensure experience. The committee was charged with developing early-career experience guidelines for engineer interns, supervisors, and mentors.

In the course of their work, both of these committees identified a need for further refinement of BOK2. For example, the Experiential Fulfillment Committee suggested additional emphasis on quality management and public safety.[21]

Taken as a whole, ASCE's experience with the development and refinement of the Civil Engineering BOK has been one of near-constant change. Immediately upon publication of the BOK1 report, it was evident that a second edition would be required. The process of implementing the BOK2 identified the need for further modifications.

Many of the short-term changes in the BOK can be attributed to the specific circumstances associated with the implementation of ASCE Policy Statement 465. No professional society had previously attempted to articulate its BOK; thus, some trial and error was perhaps inevitable. Design is inherently iterative; and, in this case, the iterations have been performed by a succession of committees, each with somewhat different perspectives.

Nonetheless, there is good reason to expect that the BOK will continue to evolve over the long term. The sociological Theory of Professions supports the notion that continuous change is an inherent characteristic of any professional BOK. In Abbott's model of the *system of professions*, the BOK is the principal means by which a profession establishes jurisdictional claims with respect to other occupational groups.[22] Because the professional environment and the relationships between professions are dynamic entities, jurisdictional claims and the associated professional bodies of knowledge are constantly in flux. As Abbott demonstrates, a strong profession must be able to adapt its BOK in response to emerging needs, opportunities, and threats.

Thus we can expect that the Civil Engineering BOK will continue to evolve over time, as a result of such influences as:

- new engineering challenges (e.g., climate change, emphasis on sustainability, energy shortages, terrorism, increase in the frequency and severity of natural disasters);
- new technologies (e.g., building information management, high-performance materials, smart buildings and sensing technologies);
- changes in the international business environment (e.g., limited financial capital, low-cost engineering services delivered via the internet, increased market consolidation);
- changes in law and the regulatory environment (e.g., licensure laws, environmental regulation);
- changes in relationships between and within engineering disciplines (e.g., evolving role of paraprofessionals); and
- engineering failures (e.g., Hurricane Katrina, Gulf oil spill, I-35 bridge collapse).

Planning for Long-Term Management of BOK and Criteria Changes

Table 2 summarizes the sequence of events associated with the development of BOK1, BOK2, and BOK1-compliant accreditation criteria. Events associated with BOK1 and BOK2 are listed in separate columns.

Note that, with the establishment of the CAP^3 Accreditation Committee in January 2004, the initiation of BOK1-compliant criteria development effectively coincided with the publication of the BOK1 report. However, in the four years since the publication of the BOK2 report, CAP^3 has chosen *not* to initiate the development of new BOK2-compliant accreditation criteria. Why not?

As the timeline suggests, the publication of the BOK2 did not fully account for the inevitable time lag associated with accreditation criteria implementation. The BOK2's publication seven months *ahead of* the first accreditation visits under BOK1-compliant criteria caused both confusion and concern among civil engineering department heads. Some programs moved aggressively to implement the BOK2 outcomes in their curricula but worried that they would still be evaluated under BOK1-compliant criteria. For others, the prospect that BOK2-compliant criteria changes might be initiated before all programs had been evaluated under the BOK1-compliant criteria caused considerable (if unfounded) angst. In either case, it can be argued that BOK2 was published too soon, at least from the perspective of criteria implementation.

DATE	EVENT	
	BOK, 1st Edition	BOK, 2nd Edition
June 2002	BOK1 Committee of CAP^3 organized	
November 2003	BOK1 finalized	
January 2004	Accreditation Committee of CAP^3 organized	
February 2004	BOK1 published	
October 2005		BOK2 Committee of CAP^3 organized
February 2006	Draft BOK1-compliant CE Program Criteria published	
July 2006	BOK1-compliant CE Program Criteria approved by ABET EAC (1st reading)	
October 2006	BOK1-compliant CE Program Criteria approved by ABET Board of Directors (1st reading)	
November 2006	Public review of CE Program Criteria initiated	
July 2007	BOK1-compliant CE Program Criteria approved by ABET EAC (2nd reading)	
October 2007	BOK1-compliant CE Program Criteria approved by ABET Board of Directors (2nd reading)	
November 2007		BOK2 finalized
February 2008		BOK2 published
September 2008	First accreditation visits under BOK1-compliant CE Program Criteria	
December 2013	Completion of six accreditation cycles under BOK1-compliant CE Program Criteria	

Table 2. Sequence of Events in the development of the Civil Engineering BOK and associated accreditation criteria

By 2011, the need for long-term synchronization of the published BOK and its associated accreditation criteria had become quite clear. That year, CAP^3 formed a special task committee to develop a strategic plan for long-term management of change. The principal objectives of this project were:

- to institutionalize the systematic review and updating of the Civil Engineering BOK;

- to keep the ABET Civil Engineering Program Criteria appropriately synchronized with the BOK; and
- to enhance BOK implementation by providing more *predictability* in the change process.

To achieve these objectives, the task committee developed, and CAP^3 approved, the long-term schedule shown in Table 3 below. The key characteristic of this schedule is a ***fixed eight-year cycle*** for both BOK updates and accreditation criteria updates. This schedule was developed by adding eight years to the implementation of BOK1-compliant accreditation criteria (September 2008), to obtain the target date for implementation of BOK2-compliant criteria (September 2016). All remaining milestones were derived from this date, using experience-based time intervals and due dates derived from Table 2.

The eight-year time interval was chosen because it can comfortably accommodate both:

- the six- to seven-year period of time required 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; and

- the six-year period required for all U.S. engineering programs to be evaluated under a new set of accreditation criteria.

Event	BOK 2nd Edition	BOK 3rd Edition	BOK 4th Edition
BOK Committee of CAP^3 organized	Already accomplished	October 2016	October 2024
BOK finalized		September 2018	September 2026
BOK published		March 2019	March 2027
Accreditation Committee of CAP^3 organized	October 2012	October 2020	October 2028
Draft CE Program Criteria published	March 2014	March 2022	March 2030
CE Program Criteria approved by ABET EAC (1st reading)	July 2014	July 2022	July 2030
CE Program Criteria approved by ABET Board of Directors (1st reading)	October 2014	October 2022	October 2030
Public Review of CE Program Criteria initiated	November 2014	November 2022	November 2030
CE Program Criteria approved by ABET EAC (2nd reading)	July 2015	July 2023	July 2031
CE Program Criteria approved by ABET Board of Directors (2nd reading)	October 2015	October 2023	October 2031
First Reviews Under New CE Program Criteria	September 2016	September 2024	September 2032

Table 3. Long-term schedule for BOK and accreditation criteria development

The principal purpose of the fixed schedule is to enhance *predictability* for civil engineering programs. With the implementation of criteria changes restricted to specified years (e.g., 2016, 2024, 2032), programs will be able to schedule routine reviews and updates of their Program Educational Objectives and Student Outcomes during these same years. Curriculum modifications and subsequent assessment of the revised objectives and outcomes can then be accomplished with a reasonable assurance of "closing the loop" before any new criteria changes occur. Thus, enhanced predictability will facilitate more effective change management.

Lessons Learned

The development of BOK-compliant accreditation criteria began with the establishment of the CAP^3 Accreditation Committee in January 2004 and continues today. During this period, the leaders of ASCE's Raise the Bar initiative have learned the following invaluable lessons about this process:

- Effective translation of BOK outcomes to accreditation criteria requires a careful balance between establishing a clear direction for curricular reform, on one hand, and avoiding excessive prescriptiveness on the other. There should be a clear mapping from BOK outcomes to criteria provisions; however, the criteria cannot possibly specify every aspect of BOK fulfillment without exceeding their purpose of establishing minimum standards.

- In conjunction with developing new criteria, there is a clear need to provide supplemental written guidance for both educators and ABET Program Evaluators. This guidance must serve two different purposes: (1) provide a rationale for each provision of the new criteria and (2) provide specific guidelines on criteria compliance. The CAP^3 Accreditation Committee chose to create a single document (the ASCE Commentary) to achieve both purposes. In retrospect, it would have been more effective to achieve these two purposes with two separate documents. The written rationale serves primarily as scholarly underpinning for the criteria and documentation of the criteria development process; once written, it becomes part of the literature and should not be changed. On the other hand, the compliance guidelines are used operationally by Program Evaluators and department heads to facilitate accreditation visits; thus, these guidelines must be kept as simple as possible and must be updated frequently, as new issues arise. These distinct differences in usage and permanence suggest that the rationale and guidelines should be promulgated in separate documents.

- The civil engineering community must recognize the dynamic nature of its professional BOK and plan for change. Periodic updates to both the Civil Engineering BOK and the associated accreditation criteria will continue to be needed. The key to developing and implementing these updates with minimum disruption is to manage change according to a predictable long-term cycle that exceeds the six-year ABET accreditation cycle.

- Persistence pays. Despite strong opposition, ASCE effected the removal of ABET's prohibition on dual-level accreditation by remaining focused on the issue for *four years*—building a scholarly rationale for change, communicating with key constituencies, 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.

References

1. "Summary Report: 1995 Civil Engineering Education Conference (CEEC '95)." American Society of Civil Engineers, Denver, CO, June 8-11, 1995.

2. "Engineering the Future of Civil Engineering—Report of the Task Committee on the First Professional Degree." American Society of Civil Engineers, May 7, 2001.

3. Russel, Jeffrey S. et al. "ASCE's Raise The Bar Initiative: Master Plan For Implementation." *Proceedings of the 2003 Annual Conference of the American Society for Engineering Education*, June 2003.

4. Body of Knowledge Committee of the Committee on Academic Prerequisites for Professional Practice. *Civil Engineering Body of Knowledge for the 21st Century: Preparing the Civil Engineer for the Future.* Reston, VA: American Society of Civil Engineers, 2004.

5. ABET EAC. "Criteria for Accrediting Engineering Programs – Effective for Reviews during the 2012-2013 Accreditation Cycle," October 2011. Accessed at http://www.abet.org/uploadedFiles/Accreditation/Accreditation_Process/Accreditation_Documents/Current/eac-criteria-2012-2013.pdf, January 10, 2012.

6. Curriculum Committee of the Committee on Academic Prerequisites for Professional Practice. "Development of Civil Engineering Curricula Supporting the Body of Knowledge for Professional Practice," American Society of Civil Engineers, December 2006.

7. "ASCE Policy Statement 465: Academic Prerequisites for Licensure and Professional Practice." American Society of Civil Engineers, June 2, 2010. Accessed at http://www.asce.org/Content.aspx?id=8376, January 10, 2012.

8. Center for the Study of Higher Education. "Engineering Change." Pennsylvania State University, College of Education. Accessed at http://www.ed.psu.edu/cshe/abet/ec2000.html, January 15, 2011.

9. Ressler, S.J. "Assessing the Standards for Assessment: Is it Time to Update Criterion 3?" *Proceedings of the 2010 Annual Conference of the American Society for Engineering Education*, June 2010.

10. Committee on Curricula and Accreditation. "Commentary on the ABET Engineering Criteria for Civil and Similarly Named Programs in the Context of the Civil Engineering Body of Knowledge," American Society of Civil Engineers, May 10, 2007.

11. "Resolution to the Engineering Deans' Council from the Public Policy Committee," June 13, 2005.

12. Smerdon, Ernest T. "Time for a Change: ABET Should Lift its Restriction Against Accrediting both Undergraduate and Master's Programs at the Same School," Prism, American Society for Engineerign Education, 14(9). Accessed at http://www.prism-magazine.org/summer05/last_word.cfm, January 10, 2012.

13. Musselman, Craig N. "It is Time to Lift the Prohibition Against Dual-Level Accreditation," *PE*, National Society of Professional Engineers, March 2007, 8.

14. Smerdon, Ernest T., et al. "Progress on Raising the Bar: Issues Related to the Prohibition on Dual-Level Accreditation of Engineering Programs, *Proceedings of the 2006 Annual Conference of the American Society for Engineering Education*, June 2006.

15. National Academy of Engineering. *Educating the Engineer of 2020: Adapting Engineering Education to the New Century*. Washington, DC: National Academies Press, 2005.

16. National Academy of Engineering. *The Engineer of 2020: Visions of Engineering in the New Century*, National Academies Press, Washington, D.C., 2004.

17. Task Committee to Plan a Summit on the Future of the Civil Engineering Profession. *The Vision for Civil Engineering in 2025—Based on the Summit on the Future of Civil Engineering, June 21 – 22, 2006*. Reston, VA: American Society of Civil Engineers, 2007. Accessed at http://www.asce.org/uploadedFiles/Vision_2025_-_New/TheVisionforCivilEngineeringin2025_ASCE.pdf, January 16, 2011.

18. ASCE. *Civil Engineering Body of Knowledge for the 21st Century: Preparing the Civil Engineer for the Future, 2nd Edition,* Reston, VA, 2008.

19. Bloom, Benjamin S. *Taxonomy of Educational Objectives*, New York: Longman, 1956.

20. Ressler, S. J., "Influence of the New Civil Engineering Body of Knowledge on Accreditation Criteria." *Proceedings of the 2008 Annual Conference of the American Society for Engineering Education*, June 2008.

21. Body of Knowledge Experiential Fulfillment Committee, "Civil Engineering Body of Knowledge—Guidelines for Attainment of the Experiential Outcomes (Draft)." ASCE, May 1, 2010. Accessed at http://www.asce.org/uploadedFiles/Competency_-_Raise_The_Bar/Reports/Guidelines%20For%20Attainment%20of%20Experiential%20Outcomes%20DRAFT--051710--web.pdf

22. Abbott, Andrew. *The System of Professions: An Essay on the Division of Expert Labor*. Chicago: University of Chicago Press, 1988.

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. <u>GENERAL CRITERIA FOR MASTERS LEVEL PROGRAMS</u>

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	3(k) An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice		
	Ability to select the appropriate tools for solving different types and levels of problems			
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	
			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.			Explain basic concepts in management
	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.			
	Asset management—effective and efficient long-term ownership of capital facilities via systematic acquisition, operation, maintenance, preservation, replacement, and disposition.			

<table>
<tr><th colspan="2">Civil Engineering Body of Knowledge</th><th colspan="3">ABET Engineering Criteria</th></tr>
<tr><th>Outcome Statement</th><th>Specific Provisions or Requirements</th><th>General Criteria for Baccalaureate Level Programs</th><th>General Criteria for Master's Level Programs</th><th>CE Program Criteria</th></tr>
<tr><td rowspan="2">14. An understanding of business and public policy and administration fundamentals</td><td>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</td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2">Explain basic concepts in business and public policy</td></tr>
<tr><td>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</td></tr>
<tr><td rowspan="3">15. An understanding of the role of the leader and leadership principles and attitudes.</td><td>Leading—broad motivation, direction, and communication knowledge and skills</td><td rowspan="3"></td><td rowspan="3"></td><td rowspan="3">Explain basic concepts in leadership</td></tr>
<tr><td>Attitudes—commitment, confidence, curiosity, entrepreneurship, high expectations, honesty, integrity, judgment, persistence, positiveness, and sensitivity</td></tr>
<tr><td>Behaviors—earning trust, trusting others, formulating and articulating vision, communication, rational thinking, openness, consistency, commitment to organizational values, and discretion with sensitive information</td></tr>
</table>

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

Kenneth J. Fridley, Ph.D., F.ASCE, *University of Alabama*

Kevin D. Hall, Ph.D., P.E., M.ASCE, *University of Arkansas*

James K. Nelson, Ph.D., P.E., C.Eng., F.ASCE, *University of Texas-Tyler*

THE RAISE THE BAR INITIATIVE: RESPONSE OF THREE CURRICULA TO ASCE'S EDUCATIONAL RECOMMENDATIONS

Abstract

Beginning in 1995 at the American Society of Civil Engineers (ASCE) Civil Engineering Education Conference (CEEC '95), key educational and professional leaders of the civil engineering community in the United States have been working to reform civil engineering education. In 1998, the call for action from CEEC '95 ultimately resulted in adoption of ASCE Policy Statement 465—Academic Prerequisites for Licensure and Professional Practice. ASCE PS 465 states that, in the future, education beyond the baccalaureate degree will be necessary for entry into the professional practice of civil engineering. In 2002, an ASCE Board-level committee, the Committee on Academic Prerequisites for Professional Practice (CAP^3), was formed to study and implement the actions that would be necessary to achieve this vision for civil engineering. The last ten years have produced significant progress in in what has been called ASCE'S "Raise the Bar" initiative.

This paper provides a review of the recommendations for formal education resulting from the "raise the bar" initiative that impact the undergraduate curriculum, and the effectiveness of the efforts to implement the recommendations based on a survey of civil engineering curricula to determine changes made in the undergraduate curriculum as a result of the recommendations. The curricular changes driven by the "raise the bar" initiative in three specific BSCE programs are reviewed.

This is one of several papers presented in recognition of the tenth anniversary of establishing CAP^3. The collective papers will provide engineering educators and practitioners with a description of the history, lessons learned, and next steps related to the "raise the bar" initiative. Collectively these present the six different aspects of the "Raise the Bar" initiative: (1) The overall initiative, (2) The civil engineering body of knowledge, (3) changed university curricula, (4) draft guidelines for professional experience, (5) revised accreditation criteria, and (6) modified licensure laws and rules.

Introduction

Beginning in 1995 at the American Society of Civil Engineers (ASCE) Civil Engineering Education Conference (CEEC '95), key educational and professional leaders of the civil engineering community in the United States have been working to reform civil engineering education. In 1998, the call for action from CEEC '95 ultimately resulted in adoption of ASCE Policy Statement 465—Academic Prerequisites for Licensure and Professional Practice. ASCE PS 465 states that, in the future, education beyond the baccalaureate degree will be necessary for entry into the professional practice of civil engineering. In 2002, an ASCE Board-level committee, the Committee on Academic Prerequisites for Professional Practice (CAP^3), was formed to study and implement the actions that would be necessary to achieve this vision for civil engineering. The last ten years have produced significant progress in in what has been called ASCE'S "Raise the Bar" initiative.

To maintain the initiative's momentum, the successful processes of the past and the associated "lessons learned" must be clearly communicated to future leaders and proponents of the "Raise the Bar" initiative. Much has been learned during the past 10 years of the "Raise the Bar" initiative. Many of these hard-learned lessons and experiences should guide the future direction of the initiative. In this regard, a quotation from Adlai E. Stevenson comes to mind: "We can chart our future clearly and wisely only when we know the path which has led to the present."

This is one of several papers presented in recognition of the tenth anniversary of establishing CAP^3. The collective set of papers will provide engineering educators and practitioners with a description of the history, lessons learned, and next steps related to the "Raise the Bar" initiative. Collectively these papers present the six different aspects of the "Raise the Bar" initiative: (1) The overall initiative, (2) The civil engineering body of knowledge, (3) changed university curricula, (4) draft guidelines for professional experience, (5) revised accreditation criteria, and (6) modified licensure laws and rules. This particular paper provides a review of the recommendations for formal education resulting from the "Raise the Bar" initiative that impact the undergraduate curriculum, and the effectiveness of the efforts to implement based on a survey of civil engineering curricula to determine changes made in the undergraduate curriculum as a result of the recommendations. The curricular changes driven by the "Raise the Bar" initiative in three specific BSCE programs are reviewed.

Compression of Engineering Curricula

Reduction of the number of credit hours in engineering curricula is a national phenomenon that has been occurring for several years. Several states have mandated that no degree program can contain more than the minimal number required by the regional accreditation boards, such as SACS, which is typically 120 credit hours. Fortunately, to this point in time, engineering programs have been able to obtain an exemption to the requirement, but those exemptions are under pressure. This reduction in the number of credit hours in an engineering degree program is causing much discussion as to whether the baccalaureate degree is adequate for professional practice in light of the expanding technology the students must learn. This question is very difficult to answer until the body of knowledge for a discipline necessary for professional practice is developed.

Table 1 Credit Hours in Engineering Degree Programs

	Credit Hours		
Statistic	All Engineering Programs in Texas	Civil Engineering Programs in Texas	Civil Engineering Programs in SEC
Mean	127.9	128.0	129.7
Median	128	128	129.5
Mode	128	128	132
Std. Dev.	3.89	3.14	2.72
Minimum	120	120	125
Maximum	139	132	134

Nevertheless, examining the current number of credit hours in engineering programs at public institutions leads to some very interesting observations. Presented in Table 1 are data regarding the number of credit hours in engineering programs in Texas and in the SEC. Data are presented for 114 baccalaureate engineering programs of all types and 13 baccalaureate civil engineering degree programs in Texas, and 12 civil engineering programs in the Southeast Conference (SEC). Interestingly, the statistics for civil engineering degree programs are about the same as for all Texas engineering programs: 128 credit hours in the program. In Texas, ninety percent of all engineering programs contain more than 120 credit hours, thirteen percent contain 125 credit hours or fewer, and 25 percent of the programs contain 130 or more credit hours. Looking only at the civil engineering degree programs in Texas, 38 percent of the programs contain 130 or more credit hours while only 15 percent contain 125 or fewer credit hours. The civil programs in the SEC tend to have more credit hours than the civil engineering programs in Texas, yet the standard deviation of the credit hours in the programs is smaller. A quick review of some civil engineering programs at private universities reveals similar data. Not that many years ago, these programs were at 135 or more credit hours.

When looking at the current data for the Texas public universities, one must also consider the Texas Common Core Curriculum which contains 44 credit hours that must be completed by all students. Of these 44 credit hours, only 14 credit hours are science and mathematics that are satisfied by the engineering curriculum. As such, approximately one academic year is dedicated to courses other than engineering, science, and mathematics courses.

Civil Engineering Body of Knowledge

A critical and necessary component of the “Raise the Bar” initiative is defining the body of knowledge necessary for a civil engineer to be placed in professional charge of a project, the point at which a civil engineer can become a licensed engineer if he or she chooses to do so. The civil engineering body of knowledge, then, embodies the knowledge, skills, and attitudes necessary for professional practice. Of primary importance of the body of knowledge as it relates to this paper is the educational component.

Development of the Body of Knowledge

The first edition of the *Civil Engineering Body of Knowledge for the 21st Century* (BOK1), released in January 2004[1], has already influenced accreditation criteria and civil engineering curricula, and is changing how future civil engineers are educated. The second edition of the *Civil Engineering Body of Knowledge for the 21st Century* (BOK2), released in February 2008[2], is also impacting civil engineering programs and curricula, and is motivating additional change in how future civil engineers are educated. Both the BOK1 and BOK2 express aspirational definitions of the knowledge, skills, and attitudes necessary for entry into the professional practice of civil engineering. The BOK1 consisted of 15 listed outcomes, including many with multiple topic areas presented as a single integrated outcome. The BOK2 is a comprehensive, coordinated list of 24 outcomes divided into three outcome categories: Foundational, Technical and Professional. Both the BOK1 and BOK2 outcomes have the desired level of achievement defined according to Bloom’s Taxonomy for the cognitive domain[2]. Additionally, the BOK1 and BOK2 have recommended outcome achievement targets for each state of the fulfillment pathway: the baccalaureate degree (B), post-baccalaureate formal education (M/30), and pre-licensure experience (E).

Recommendations for Education

The first edition of the *Civil Engineering Body of Knowledge*[1] presented the 15 outcomes using a three-tiered model for achievement. The Curriculum Committee of CAP[3] was charged with reviewing the BOK1 and to develop sample curricula the supported the BOK1. One of the major contributions of the Curriculum Committee was a review of the educational development literature to find an appropriate framework that could link body of knowledge outcomes to actual learning and achievement. The committee's recommendation, as presented in the "Levels of Achievement Report" was to adopt Bloom's Taxonomy[5], which is widely known and understood within the educational and engineering education communities. This was a significant development in the "Raise the Bar" initiative as expected levels of achievement could be tied to demonstrable student achievement.

Bloom's taxonomy employs three distinct domains—the cognitive, the affective, and the psychomotor. The cognitive domain deals with the recall or recognition of knowledge and the development of intellectual abilities and skills. The affective domain involves interest, attitudes, and values. Finally, the psychomotor domain relates to manipulative or motor-skills. The cognitive domain has the most direct application here because its addresses many of the conventional learning outcomes associated with engineering and is aligned well with the engineering process.

The cognitive domain within Bloom's Taxonomy has six defined levels of achievement (LOA):

> Level 1 – Knowledge: simple recollection of previously learned material, which may range from specific facts to complete theories.
>
> Level 2 – Comprehension: explaining or describing the meaning of learned material, including perhaps estimating possible future trends.
>
> Level 3 – Application: use learned material in new situations to solve new problems.
>
> Level 4 – Analysis: breaking down learned and new material into basic component parts or principles, including defining relationships between parts.
>
> Level 5 – Synthesis: creating new knowledge or designing new systems, either uniquely or putting together existing components to form a new whole.
>
> Level 6 – Evaluation: judging the relative merit or value of material for a defined purpose, including examining potential impacts and ramifications.

To assess the impact of the BOK1 and BOK2 on civil engineering curricula and to facilitate broad adoption of the new BOK concepts in civil engineering education, the ASCE Committee on Academic Prerequisites for Professional Practice (CAP[3]) established the BOK Educational Fulfillment Committee (BOKEdFC). This committee was established to explore how the vision of the BOK, specifically formal educational experiences, can be realized in the future. The work of the BOKEdFC has been documented through a series of papers presented and published as part of the ASEE Annual Conference. The first portion of the committee's effort focused on how well programs, in their current design, achieve the educational outcomes of both the first and second editions of the civil engineering BOK[1,2]. The following is a list of outcomes the committee deemed "challenging" based on their review: Outcome 3 – Humanities; Outcome 4 –

Social Sciences; Outcome 5 – Material Science; Outcome 10 – Sustainability; Outcome 11 – Contemporary Issues and History; Outcome 12 – Risk and Uncertainty; Outcome 17 – Public Policy; Outcome 18 – Business and Public Administration; Outcome 19 – Globalization; Outcome 20 – Leadership; and Outcome 24 – Professional and Ethical.

The second phase of the BOKEdFC's effort was chronicled in a series of papers presented and published in 2010. In these papers, individual programs conducted in-depth reviews of their respective curricula and determined, outcome-by-outcome, how well their graduates fulfilled the outcomes with specific attention to the identified "challenging" outcomes. Their reviews are accompanied by possible curricular changes needed to address any short-comings. These papers serve as a series of case studies encompassing a broad range of program types and ways to address common difficulties with some of the BOK2 outcomes.

Implementation in Civil Engineering Curricula

For the efforts of defining a civil engineering body of knowledge to have an impact, a beneficial impact, on the profession, the body of knowledge must be embodied by the profession. A key component of that embodiment is the manner in which the educational components are implemented in civil engineering curricula.

Broad Overview of Curricular Change

As a result of the "Raise the Bar" initiative, expected program outcomes have increased from 13 with the traditional "ABET a-k" to 15 outcomes in Civil Engineering BOK1 to 24 outcomes in Civil Engineering BOK2. In some cases the additional outcomes resulted from splitting previous outcomes to better clarify the intention, but in other cases there are additional outcomes. Further, some outcomes have been broadened in the context of current technological changes. In this section of the paper, the changes in program outcomes for three specific programs are presented to illustrate the impact on curricula.

Implementation at the University of Alabama

The University of Alabama is a major, comprehensive, student-centered research university founded in 1831. Courses in civil engineering were first offered in 1837. Today, the University of Alabama enrolls over 32,000 students and contributes over $2.1 billion to the state's economy. The College of Engineering, with approximately 110 tenure/tenure-track faculty members in seven departments, enrolls over 3,000 undergraduate, 200 masters, and 140 doctoral students. The Department of Civil, Construction, and Environmental Engineering has 20 tenure/tenure-track faculty, enrolls over 600 undergraduate, 38 masters, and 32 doctoral students. The department participates in many interdisciplinary research centers and is lead in three—the Aging Infrastructure Systems Center, the Environmental Institute, and the University Transportation Center for Alabama.

The department offers two ABET/EAC-accredit degrees, the BS in Civil Engineering (which is the focus of this paper) and the BS in Construction Engineering. The BSCE has been continuously accredited by ABET since 1936. A major curricular redesign was completed and implemented in 2004 that addressed various local and national issues, including the BOK1 report. In 2008, following the release of the BOK2 report, a review of the BSCE curriculum and student learning outcomes was conducted. Some adjustments to specific course content were made and a revised set of program outcomes was developed and implemented fall 2009. As part of another review, specifically considering graduate program learning outcomes in support of the institution's SACS accreditation effort, the learning outcomes were once again modified slightly in the Fall 2011 to allow integration and continuity with the new graduate-level outcomes.

The program outcomes used until fall 2004 were, in essence, a restatement of the ABET 3a-k and civil engineering program criteria. Effective from fall 2004 through fall 2009, the program's outcomes were structured based on the BOK1 as restated in the Curriculum Committee's Level of Achievement Report using Bloom's Taxonomy. The program's 12 outcomes were presented in two categories – technical (T1 – T7) and professional practice (P1 – P5) utilizing Bloom's taxonomy to establish the level of achievement. Beginning Fall 2009, the program's 14 outcomes were divided into three categories – foundational (F1 – F2), technical (T1 – T7), and professional practice (P1 – P5). All components of the 2004 outcomes were incorporated in the new 2009 outcomes**,** with some reorganization and renumbering. Other changes were the result of consideration of the BOK2 outcomes and the addition of the new BS in Construction Engineering program. For fall 2011, only modest modifications were made to the undergraduate outcomes, with all changes being based on input from the program's constituencies. The significant change was the addition of a coordinated and integrated set of graduate level outcomes to support the program's SACS accreditation efforts. Additional discussion of the impact on program outcomes is provided in a subsequent section of this paper.

The curriculum was designed to support the learning outcomes and abide by the university's policies. It also had to support an expected growth in undergraduate enrollment. The university had a vision to grow, so the department took this opportunity to design a curriculum that would be both attractive to highly qualified students and be sustainable with a projected 100% enrollment growth (actual growth is closer to 150%). The primary university constraints relate to credit hour and core curriculum requirements. Full time status is limited to 12-16 hours per semester, thereby setting an effective cap on total credit hours of 128. The university has a core curriculum requirement which includes 6 semester hours of freshman composition, 6 hours of "writing within the curriculum" in 300- and 400-level courses, 9 hours of humanities, literature, and fine arts, 9 hours of history and social and behavioral sciences, and 12 hours of natural science and mathematics to include 2 hours of laboratory.

The curriculum was designed to adhere to the constraints and have its graduates fulfill the outcomes. One of the features of the new curricular design was creating a total of 18 semester hours of senior "plan of study" electives the curriculum. Of the 18 hours, a minimum of 6 hours must be civil engineering "design-designated" electives and a maximum of 6 hours may be "professional practice" electives. The department maintains a listing of approved design-designated courses (which include a significant design experience) and professional-practice courses. While a few CE courses are listed as professional-practice, most of these courses are from outside the department (e.g., business, other engineering disciplines, etc.).

To help with planning and advising, and the flexibility allowed with the 18 hours of senior electives, the faculty developed a suite of minors. The majority of students opt to pursue one or more minors to complement their BSCE degree. The department maintains six minors—architectural engineering, civil engineering (for non-majors), construction engineering, environmental and water resources engineering, structural engineering, and transportation engineering. In addition, minors in business administration, mathematics, foreign language and other areas are commonly pursued. When pursuing a minor outside the department, often the allowed two professional-practice electives are used towards the minor.

The University of Alabama BSCE program outcomes have evolved over time, largely in response to the ASCE BOK1 and BOK2 reports. Accordingly, curricular and course-content changes have been made to support the new and revised program outcomes. So too has changes been made to the assessment program. All outcomes are linked to at least two courses (more for most outcomes) within the curriculum. Within each civil engineering course, students are required to submit a “course outcome portfolio” wherein the student documents their achievement of the course outcomes. At graduation and as part of the senior design course, students are required to submit a “graduation portfolio” in which the student documents their achievement of all program outcomes. The instructor, as a part of the course grade, evaluates course-level portfolios. Department faculty and members of the department’s external advisory board evaluate graduation portfolios.

Most of the curricular and course-content changes to support the change from the original program outcomes to the new program outcomes were made as a result of potential lack of educational development relative to one or more of the new outcomes. The result of the curricular and course-content changes was a curriculum that provides learning and assessment opportunities in support of the program outcomes.

The curriculum, as it existed in 2003 prior to any changes related to the BOK and as it stands today as influenced by the BOK, is presented in Appendix I. A summary of the credit hours is shown in Table 2 below. It should be noted, though, that with today’s curriculum students may select additional engineer design, engineering science, natural or physical science, or mathematics courses with their senior “plan of study” electives. A minimum of 6 hours of these 36 hours of electives must be engineering design and a maximum of 6 hours may be what is termed “professional practice” electives, which may include math, science, business, or other appropriate electives. Additionally, the program today does not maintain a strict credit hour accounting system for engineering design versus engineering science. Rather, courses with “a significant and documentable design experience that achieves Bloom’s Level 5” are identified as “design-designated courses.” Thus, in Table 2, the credit hours provided are both a minimum and approximate for engineering design and engineering science.

Table 2 Program Hours at the University of Alabama from 2003 to Present

Subject Area	2003	Today
English, Humanities, Social Studies	24	24
Mathematics (min)	18	18
Physical Science (min)	16	16
Engineering Science (min)	51	36
Engineering Design (min)	13	15
TOTAL	132	125

Implementation at the University of Arkansas

The University of Arkansas is a Carnegie I research university founded in 1871. The Department of Civil Engineering has 15 tenure/tenure-track faculty members and enrolls approximately 200 undergraduate, 35 masters, and 13 doctoral students. In addition to the MS and PhD in Civil Engineering, the department offers two degree programs accredited by the EAC of ABET, Inc. – a BS in Civil Engineering (continuously accredited since 1936) and an MS in Environmental Engineering (accredited since 2003). The BSCE will be the focus of this paper.

Historically the program outcomes for the BSCE reproduced (verbatim) ABET criterion 3a-k. In 2002 the outcomes were restated with increased specificity to civil engineering; three additional outcomes were added to reflect then-current civil engineering basic level program criteria. All outcomes were written in the style of ABET "EC 2000." In 2010, following the release of the BOK2 report in 2008, a comprehensive review of the BSCE curriculum was conducted—with a particular emphasis on establishing student learning outcomes throughout the curriculum. Course-by-course student learning outcomes were developed and stated in a format compatible with the outcomes contained in BOK2. Thus, the initial impact of the BOK on the Arkansas BSCE curriculum related to applying the concept of student cognitive development (e.g. Bloom's taxonomy) to individual courses.

The natural 'next step' in the evolution of the BSCE program was to map student learning outcomes from individual courses to ABET program outcomes. Initial efforts – in which BOK-style course outcomes were to be mapped to ABET EC2000-style program outcomes – proved difficult. In 2010, the BSCE program outcomes were completely redeveloped and adopted by the faculty. The primary influence on this redevelopment was the BOK2; faculty and external advisory committees agreed that the program would move towards "compliance" with the BOK2, while staying compatible with current ABET accreditation criteria. This effort resulted in a total of thirteen program outcomes, which cover the breadth of the principles included in the BOK2.

In 2011 two external forces have resulted in changes to the BSCE program. The University of Arkansas is strictly enforcing the statewide 'core curriculum' for Arkansas institutions of higher education. Formerly, the engineering programs at the University of Arkansas enjoyed an exception to the state core requirements by specifying humanities and social science (H&S) courses based on an interpretation of ABET EC2000 criteria. This allowed advanced-level H&S courses in the curriculum. With the enforcement of the statewide core, all H&S courses are limited to entry or basic-level (1000- and 2000-level). A full assessment of this change has not been completed; however, there is a concern that basic-level H&S courses may not provide BSCE students the knowledge necessary to reach the level of achievement specified in the related program outcomes. The second issue stems from the Arkansas legislature enacting Act 747 of 2011, which limits baccalaureate degrees at Arkansas' public institutions of higher education to 120 hours. Programs with external constraints, e.g. accreditation requirements, may seek exceptions to the Act. The College of Engineering at the University of Arkansas seeks to set all undergraduate programs at 128 hours or less. Consequently, the BSCE program is in the process of being reduced from 132 hours (the total hours since 2000) to 128 hours. As part of this reduction, the content of numerous courses (and course credit hours) have been adjusted; at this point, it does not appear that the program outcomes will be affected by the reduction in hours. Table 3 illustrates the relatively minimal effect of changes in program hours in various subject areas.

The BSCE program outcomes of the University of Arkansas have undergone more changes in the past few years than at any point in its history. These changes are a direct response to the ASCE BOK2. There have been associated changes to both the courses in the curriculum and the content of existing courses. The major task in the immediate term to accompany curriculum and program outcome changes is a major revision to assessment procedures. It is anticipated that assessment may be improved due to the practice of stating student learning outcomes, at both the program and individual course levels, in terms of levels of achievement—another direct effect of the BOK2.

Table 3 Program Hours at the University of Arkansas from 2005 to Present

	Credit Hours	
Subject Area	2005	Today
English, Humanities, Social Studies	24	24
Mathematics	19	18
Physical Science	17	15
Engineering Science	37	36
Engineering Design	35	35
Total Credit Hours	132	128

Implementation at The University of Texas at Tyler

The University of Texas at Tyler was established in 1971 as Tyler State College, which was a comprehensive upper-level institution. The University became a part of The University of Texas System in 1979, as a result of action by the 66th Texas Legislature. The mission of UT Tyler mission was expanded in 1997 when the 75th Texas Legislature passed House Bill 1795 authorizing it to offer classes for freshman and sophomore students. Governor George W. Bush signed the bill into law on May 26, 1997. In fall 2011, the University enrolled approximately 6,700 students, of which approximately 1,600 are graduate students. Students at the University represent 35 states, 45 nations, and 131 countries. It employs 388 faculty members and has research expenditures of more than $12 million.

The College of Engineering is the youngest college in the University, being founded in 1998 with two engineering programs: electrical engineering and mechanical engineering. When the University was reorganized in 2002, Computer Science became a part of the college. The civil engineering program is the youngest engineering program in the college; it was founded in fall 2005 and the first students graduated in spring 2008. The college enrolls nearly 700 students and employs 28 faculty members.

The civil engineering undergraduate curriculum was implemented after publication of the first edition of the Civil Engineering Body of Knowledge by ASCE[1]. As such, the faculty developed program outcomes and the curriculum with full knowledge of the civil engineering body of knowledge. Because there was no previous curriculum to deal with, this curriculum represents a "clean" implementation of the body of knowledge, as it existed at that point in time. The curriculum, as it existed at that time is presented in Appendix III, and the breakdown of the credit hours is shown in Table 4 below. At the time of the first EAC/ABET accreditation visit in fall 2008, no weaknesses or deficiencies were noted in the program at the time of the visit.

Table 4 Program Hours at The University of Texas at Tyler from 2005-Present

	Credit Hours	
Subject Area	2005	Today
English, Humanities, Social Studies	33	30
Mathematics	18	18
Physical Science	15	15
Engineering Science	49	51
Engineering Design	13	14
Total Credit Hours	128	128

Regional employers were consulted regarding the program of study. Further the program was reviewed by the department's external advisory council, which was composed of private and public employers as well as a dean from another institution outside of Texas. Employers and the external advisory council, as well as the students and faculty, continue to be an integral part of the assessment process. The sources of input provided by the different constituencies, internal and external, are shown all considered during assessment for continuous improvement.

Following publication of BOK2 report in 2008, a comprehensive review of the BSCE curriculum was conducted to ensure that it embodied the revised program outcomes contained in that document. The curriculum as it exists today is also presented in Appendix III and the breakdown of credit hours is shown in Table 4 above. The changes in the program outcomes are presented later in this paper. An impact of the civil engineering BOK is that student learning outcomes were an integral part of the curriculum from the beginning and these outcomes were mapped to the civil engineering program outcomes.

Assessment of Impact of "Raise the Bar" on Curricula

The impact of the "Raise the Bar" initiative on civil engineering curricula is assessed from three perspectives, namely:

- **Changes in program outcomes:** One measure of impact is the changes that have occurred in the defined Program Outcomes from 2000 to 2011. The changes in the outcomes at the three programs for which curricular changes were discussed are assessed in this context.
- **Changes in Courses included in the Curriculum:** Another measure is the impact of "Raise the Bar" is the changes in the "mix" of courses that are included in the curricula. Included in the mix of courses is change that may have occurred in the manner in which core education courses are used to the advantage of "Raise the Bar." The changes in the course mix at the three programs for which curricular changes were discussed are assessed in this context.

The University of Alabama

Prior to the BOK1, the University of Alabama's student learning outcomes were basically recast ABET outcomes as follows:

1. Graduates must demonstrate an understanding and reasonable compliance with the following as they apply to civil engineering:
    a. an ability to apply knowledge of mathematics (through differential equations and probability and statistics), science (including calculus-based physics and general chemistry), and engineering;
    b. an ability to function on multidisciplinary teams,
    c. an ability to identify, formulate, and solve engineering problems,
    d. an understanding of professional and ethical responsibility,
    e. an ability to communicate effectively,
    f. a knowledge of contemporary issues, and
    g. an ability to design and conduct experiments, as well as to analyze and interpret data.

2. Graduates will be capable of performing civil engineering design from exposure to design experiences integrated throughout the professional component of the curriculum culminating in a major design experience.

3. Graduates will understand civil engineering professional practice issues such as:
    a. Procurement of work, bidding versus quality-based selection process, how design professionals and the construction profession interact to construct a project,
    b. The impact of civil engineering solutions in a global and societal context and
    c. The importance of professional licensure and continuing education in lifelong learning.

4. Graduates will have proficiency in at least four of the following areas:
    a. Environmental engineering,
    b. Structural engineering,
    c. Geotechnical engineering,
    d. Water resources engineering, and
    e. Transportation engineering.

The student learning outcomes were completely rewritten following the release of the BOK1 and subsequently modified based on the outcomes provided in the BOK2. The current program objectives and student learning outcomes are as follows:

2012 CIVIL AND CONSTRUCTION ENGINEERING PROGRAM OBJECTIVES:

The objective of the University of Alabama's **bachelor of science in civil engineering** (BSCE) and **bachelor of science in construction engineering** (BSConE) programs is to graduate students who are in demand by employers and graduate programs and who lead fulfilling professional careers through their abilities to:

1) Apply foundational knowledge of mathematics, science, humanities, and social sciences in the professional practice of civil or construction engineering ~~Solve fundamental civil or construction engineering problems~~;
2) Synthesize technical knowledge of engineering analysis and design to identify, formulate, and solve civil or construction engineering problems ~~Articulate his or her responsibilities to the profession and society~~; and
3) Demonstrate ~~a basic level of achievement in~~ the professional practice skills needed to be successful in ~~the practice~~ civil or construction engineering.

CIVIL AND CONSTRUCTION ENGINEERING STUDENT LEARNING OUTCOMES:

The BSCE and BSConE student learning outcomes are formulated into three categories: *Foundational, Technical* and *Professional Practice* Outcomes. Graduates of The University of Alabama BSCE and BSConE programs will be able to:

Foundational Outcomes:

Outcome F1 (*Level 3*): **Solve** problems in mathematics through differential equations, probability and statistics, calculus-based physics, general chemistry, and one additional area of science.

Outcome F2 (*Level 3*): **Explain** the importance of (1) humanities, literature, and fine arts, and (2) history and social behavior ~~in the professional practice of civil or construction engineering~~.

Technical Outcomes:

Outcome T1 *(Level 4)*: **Analyze** and **solve** problems in material science and engineering mechanics ~~mechanics of solids, and mechanics of fluids~~.

Outcome T2 *(Level 4)*: **Select** and **conduct** program-relevant civil or construction engineering experiments to meet a need, and **analyze** and **evaluate** the resulting data.

Outcome T3 *(Level 3)*: **Apply** relevant knowledge, techniques, skills, and modern engineering tools to identify, formulate, and solve engineering problems, including:

BSCE – problems in at least four technical areas appropriate to civil engineering

BSConE – problems in construction processes, communications, methods, materials, systems, equipment, planning, scheduling, safety, economics, accounting, cost analysis and control, decision analysis, and optimization.

Outcome T4 *(Level 3)*: **Explain** the impact of historical and contemporary issues on civil or construction engineering~~, and **predict** possible impacts of a specific, relatively constrained engineering solution on the economy, environment, and society~~.

Outcome T5 *(Level 3)*: **Develop** solutions to well-defined project management problems within civil or construction engineering.

Outcome T6 *(Level 5)*: **Design** a system or process in more than one program-relevant civil or construction engineering specialty field to meet desired needs, including sustainability and within other realistic constraints such as economic, environmental, social, political, ethical, health and safety, and constructability.

Outcome T7 *(Level 2)*: **Explain** key aspects of at least one traditional or emerging program-relevant area of advanced specialization.

Professional Practice Outcomes:

Outcome P1 *(Level 4)*: **Analyze** a situation involving multiple conflicting professional, legal, and ethical interests to determine an appropriate course of action.

Outcome P2 *(Level 4)*: **Organize** and **deliver** effective written, verbal, graphical and virtual communications.

Outcome P3 *(Level 3)*: **Demonstrate** the ability to learn through independent study, without the aid of formal instruction.

Outcome P4 *(Level 3)*: **Demonstrate** attributes supportive of the professional practice of engineering; **apply** leadership principles to direct the efforts of a small group to solve a relatively constrained problem; and **function** effectively as a member of a multidisciplinary team to solve open-ended engineering problems.

Outcome P5 *(Level 2)*: **Explain** the importance of licensure, and basic concepts in engineering management, business, law, public administration, public policy, and globalization as related to the professional practice of civil or construction engineering.

The University of Arkansas

Program outcomes for the BSCE at the University of Arkansas were written for compatibility with the ABET EC2000 criteria prior to the release of the BOK. A listing of these outcomes follows.

Students must demonstrate:

a) an ability to apply knowledge of mathematics, and science in the solution of engineering problems
b) an ability to design and conduct civil engineering experiments and analyze and interpret the resulting data
c) an ability to design a system, component, or process to meet desired needs within the context of at least two civil engineering areas and considering realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
d) an ability to function on multi-disciplinary teams
e) an ability to apply knowledge of the environmental, geotechnical, structural, and transportation areas to the solution of engineering problems
f) an ability to identify, formulate, and solve engineering problems
g) an understanding of professional and ethical responsibility including the importance of professional licensure.
h) an ability to communicate effectively
i) the broad education necessary to understand the impact of engineering
j) a recognition of the need for, and an ability to engage in life-long learning
k) a knowledge of contemporary issues
l) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.
m) an ability to explain the basic concepts in management, business, public policy, and leadership solutions in a global, economic, environmental, and societal context

In 2010, program outcomes were rewritten to move the program and its curriculum towards increased ‘compliance’ with the BOK2. As noted in the listing which follows, the number of program outcomes remained the same (13); however, the specificity of outcomes increased, and the format of the outcome statements reflects the BOK2 ‘style’ of relating student achievement with levels of cognitive development.

(1) **Solve** problems in mathematics through differential equations, probability and statistics, calculus-based physics, general chemistry, and one additional area of science.
(2) **Select** and **conduct** relevant experiments in multiple areas of civil engineering, and **analyze** and **evaluate** the resulting data.

(3) Design a system, component, or process to meet desired needs within at least two program-relevant civil engineering areas, considering the principles of sustainability and including realistic constraints such as economic, environmental, social, political, ethical, health and safety, and constructability.

(4) Apply leadership principles to direct the efforts of a small group to solve a relatively constrained problem; and **function** effectively as a member of a multidisciplinary team to solve open-ended engineering problems.

(5) Apply relevant knowledge, techniques, skills, and modern engineering tools to **identify**, **formulate**, and **solve** engineering problems, including problems in at least four technical areas appropriate to civil engineering, and including problems containing uncertainty.

(6) Explain the concept of 'professionalism'; **discuss** the importance of professional ethics and the importance of professional licensure.

(7) Analyze a situation involving multiple conflicting professional, legal, and ethical interests to determine an appropriate course of action.

(8) Organize and **deliver** effective verbal, written, virtual, and graphical communications.

(9) Explain the importance of humanities, history, and social behavior in the professional practice of civil engineering.

(10) Demonstrate the ability to learn through independent study, without the aid of formal instruction.

(11) Explain the impact of historical and contemporary issues on the identification, formulation, and solution of engineering problems and **identify** possible impacts of engineering solutions on the economy, environment, political landscape, and society.

(12) Explain key concepts and processes used in business, public administration, and public policy.

(13) Develop solutions to well-defined project management problems within civil engineering.

<u>The University of Texas at Tyler</u>

Again, the civil engineering program at The University of Texas Tyler was developed with full knowledge of BOK1. As such, the changes in the program outcomes as a result of the "Raise the Bar" initiative are not as pronounced as they may be at other institutions. Nevertheless, changes have occurred since the inception of the program.

Following are the current Program Outcomes for the Bachelor of Science in Civil Engineering:

1. Produce Civil Engineering graduates who:
    a. Can apply knowledge of traditional mathematics to solve problems
    b. Can apply knowledge of traditional science (calculus-based physics, Chemistry, additional science) to solve problems
    c. Can apply knowledge of traditional engineering skills to solve problems
    d. Can use modern engineering tools to solve problems
2. Produce Civil Engineering graduates who can design and conduct experiments, as well as analyze and interpret data in more than one civil engineering discipline

3. Produce Civil Engineering graduates who:
    a. Can design systems, components, and processes
    b. Can recognize the strengths and areas for possible improvement of their creative designs
4. Produce Civil Engineering graduates who can work independently as well as part of a multidisciplinary design team
5. Produce Civil Engineering graduates who:
    a. Can identify, formulate, solve and evaluate engineering design problems using engineering models in the discipline of structural engineering
    b. Can identify, formulate, solve and evaluate engineering design problems using engineering models in the discipline of transportation engineering
    c. Can identify, formulate, solve and evaluate engineering design problems using engineering models in the discipline of construction management
    d. Can identify, formulate, solve and evaluate engineering design problems using engineering models in the discipline of hydrology and hydraulic design
    e. Can identify, formulate, solve and evaluate engineering design problems using engineering models in the discipline of environmental engineering design
    f. Can identify, formulate, solve and evaluate engineering design problems using engineering models in the discipline of environmental engineering design
6. Produce Civil Engineering graduates who:
    a. Can analyze a situation and make appropriate professional decisions
    b. Can analyze a situation and make appropriate ethical decisions
7. Produce Civil Engineering graduates who Have effective oral, written, and graphical communication skills
8. Produce Civil Engineering graduates who:
    a. Demonstrate a commitment to learning and continued professional development outside the classroom
    b. Incorporate contemporary issues during problem solving
    c. Determine the impact of engineering solutions in a global and societal context
9. Produce Civil Engineering graduates who:
    a. Can explain professional practice issues
    b. Can explain leadership principles and attitudes
    c. Can explain management concepts and processes
    d. Can explain concepts of business practices
    e. Can explain public policy and public administration
10. Produce Civil Engineering graduates who can demonstrate the importance of humanities in the professional practice of civil engineering
11. Produce Civil Engineering graduates who can demonstrate the incorporation of social sciences knowledge into the professional practice of civil engineering
12. Produce Civil Engineering graduates who can use the knowledge of material sciences to solve problems appropriate to civil engineering
13. Produce Civil Engineering graduates who:
    a. Can analyze and solve problems in solid mechanics
    b. Can analyze and solve problems in fluid mechanics
14. Produce Civil Engineering graduates who can apply principles of sustainability to the design of traditional and emergent engineering systems

15. Produce Civil Engineering graduates who can apply the principles of probability and statistics to solve problems containing uncertainties and risk assessment

Of these 15 outcomes, those that are shaded were added to address the content of BOK2. These outcomes include the “softer” outcomes deemed necessary for civil engineering practice in the current and anticipated future design environment, as well as more explicit definition of hard subject outcomes, such as fluid mechanics. A review of the curricula presented in Appendix III shows the manner in which the course content of the curriculum has changed to address these additional outcomes.

Curricular Impact – Course Mix

Presented in Tables 2, 3 and 4 are the changes to total hours required in the three example programs, as well as adjustments to the ‘mix’ of courses in the curriculum. Table 5 summarizes these changes. The initial impression from the data in Table 5 is that program changes in response to the BOK do not necessarily require major adjustments to the mixture of courses in the curriculum (recall the relatively large change in “Engineering Science” for the University of Alabama is likely due to the method of accounting for this designation, rather than changes to course requirements).

Overall, no patterns exist in this data snapshot of three programs. This suggests that individual programs make adjustments as needed to not only respond to curricular reform efforts by the profession, but also to meet external requirements imposed by university administration, state legislatures, or other bodies. In other words, within the sphere of ABET, total program requirements remain relatively unique to a given institution; an effort such as Raise the Bar represents only one force acting on program requirements.

Table 5 Changes to Course Mix, 2005-Present

	Program		
Subject Area	Alabama[a]	Arkansas	UT Tyler
English, Humanities, Social Studies	0	0	-3
Mathematics	0	-2	0
Physical Science	0	-1	0
Engineering Science	-15	-1	+ 2
Engineering Design	+ 2	0	+ 1

[a]Alabama data reflects changes from 2003-Present

Other Efforts Building upon “Raise the Bar”

The Texas Higher Education Coordinating Board’s (THECB) goal of supporting the development of 2+2 programs to more fully and efficiently use the community college pathway to baccalaureate degrees began with the Voluntary Mechanical Engineering Transfer Compact (ME Compact). The ME Compact was developed in 2009 as a pilot project by the THECB, with grant support from Lumina Foundation for Education (Lumina) and the work of a voluntary advisory committee made up of engineering deans and their designees from across Texas. The more specific goal of the project was to identify a set of lower-division courses, up to the level of an associate's degree, that would provide the necessary academic background to integrate a mechanical engineering student seamlessly into participating mechanical engineering programs at 4-year institutions. The broader goal of the project was to develop a collaborative process that could be utilized to develop voluntary statewide compacts for additional disciplines. To date, the chancellors or presidents of 14 universities and 34 community and technical colleges or systems have agreed to participate in the ME Compact, eliminating the need for potentially over 475 institution-to-institution articulation agreements among these signatory institutions.

Due in part to the success of the pilot project, Texas became eligible and successfully competed for a four-year "Productivity Grant" from Lumina to implement plans to improve college completion rates and reduce the cost and time to degree. In 2010 and as part of this grant-supported project, Texas began integrating the "Tuning" process into the course alignment work that was piloted in 2009 through the efforts of the Voluntary Mechanical Engineering Transfer Compact Committee. Tuning is a faculty-led process that is designed to define what students must know, understand, and be able to demonstrate after completing a degree in a specific field, and to provide an indication of the knowledge, skills, and abilities students should achieve prior to graduation at different degree levels (i.e., associate's degree, bachelor's degree, etc.) – in other words, a body of knowledge and skills for an academic discipline in terms of outcomes and levels of achievement of its graduates. It involves creating a framework that establishes clear learning expectations for students in each subject area while balancing the need among programs to retain their academic autonomy and flexibility. The objective is not to standardize programs offered by different institutions but to better establish the quality and relevance of degrees in various academic disciplines.

With the help of faculty who comprised the 2010 Tuning Oversight Council for Engineering, Texas now has final Tuning packages and voluntary transfer compacts for Civil, Electrical, Industrial, and Mechanical Engineering. "Year Two" of Tuning Texas is well underway, including Tuning work on two additional engineering disciplines (Biomedical and Chemical Engineering) and two areas of science (Biology and Chemistry). "Year Three" of Tuning Texas began in February 2012 with the 2012 Tuning Oversight Council for Mathematics, Business, and Computer/Management Information Systems. "Year Four" of Tuning Texas will begin in February 2013 with Tuning work on additional high-need and high-demand disciplines. These efforts have all drawn extensively from the work of ASCE through its "Raise the Bar" initiative.

A model community college associate's degree program that provides a statewide standard of achievement for students in pre-engineering programs, and that is recognized as an achieved body of knowledge for admission by engineering programs at 4-year institutions, was the next natural step to make the migration of community college engineering students into Texas universities for bachelor's degree completion more efficient and more seamless. The curricular content of the Associate of Science Degree in Engineering Science provides students with increased flexibility in selecting an appropriate engineering program at a participating 4-year institution, and minimizes the time to completion of the baccalaureate degree for students who choose this pathway. A critical component of the model program is that the degree will be accredited by the Applied Science Accreditation Commission of ABET (ASAC/ABET) at each participating community college to ensure the same standards of achievement as those that exist at ABET-accredited engineering degree programs at 4-year institutions. Students completing the program of study and graduating with the associate's degree from a community college will be immediately accepted into a participating 4-year institution of their choice (space permitting, meeting GPA requirements, etc.) to complete a baccalaureate engineering degree. The degree program pathway demonstrates the true spirit of both the *Closing the Gaps* (4) and the Texas Tuning initiatives.

As stated previously, the voluntary statewide articulation compacts and the Associate of Science in Engineering Science degree program represent parallel pathways to the engineering degree. These pathways are parallel to a third pathway, which is matriculation into a baccalaureate engineering program as a freshman. Of the pathways through the community college system, the Associate of Science in Engineering Science provides the student with the greatest flexibility and with the least opportunity for "misadvising" and lost coursework. That degree program, and its development and implementation, is discussed herein. The program was made feasible because of the horizontal course alignment, alignment in regard to content and learning outcomes to be achieved, conducted through the "tuning" process briefly discussed.

Conclusions and Recommendations

The Civil Engineering Bodies of Knowledge (BOK1 and BOK2) that have been developed by the American Society of Civil Engineers have taken considerable steps to define the breadth and depth of knowledge that will be expected of civil engineers in the future. This breadth and depth is greater that it has been in the past with the rapid technological advances that have been occurring. Although the foundational skills remain the same, the total breadth of skills deemed necessary for successful practice has increased. As these changes are affecting accreditation criteria, civil engineering degree programs must respond to these increased expectations in regard to breadth and depth. The implementation at three institutions has been reviewed in this paper. From a review of these implementations, two general conclusions can be drawn:

a. Civil engineering programs are responding to the recommendations of the BOK through change in the curriculum; and
b. With little question, at least on the part of the authors, the increased expectations are becoming increasingly difficulty to accommodate with the size of the common core curriculum (general education requirements) at most institutions and with the emphasis on decreasing the total number of credit hours permitted in a curriculum.

As civil engineering moves forward into the 21st century, indeed as all engineering programs move into the 21st century, considerable attention will need to be given to the pressure to reduce credit hours if well-educated engineers are to be produced. In the view of the authors, the reduction of maximum credit hours will need to subside, or engineering may need to move towards professional programs as medicine, law, and other professions have done.

References

1. American Society of Civil Engineers, *Civil Engineering Body of Knowledge for the 21st Century*, Reston, Virginia, American Society of Civil Engineers, 2004.

2. American Society of Civil Engineers, *Civil Engineering Body of Knowledge for the 21st Century: Preparing the Civil Engineer for the Future (2nd edition).* Reston, Virginia: American Society of Civil Engineers, 2008.

3. The Engineer of 2020: Visions of Engineering in the New Century, National Academy of Engineering, The National Academies Press, 2004.

4. Texas Higher Education Coordinating Board. (2011). Closing the Gaps Progress Report 2010. Retrieved from http://www.thecb.state.tx.us/reports/PDF/2357.PDF?CFID=16095327&CFTOKEN=58659160

5. ASCE Levels of Achievement Subcommittee. 2005. *Levels of Achievement Applicable to the Body of Knowledge Required for Entry Into the Practice of Civil Engineering at the Professional Level,* Reston, VA, September. (http://www.asce.org/raisethebar)

Appendix I—Civil Engineering Curricula at the University of Alabama

Following is the curriculum at the University of Alabama effective fall 2002 (pre-BOK).

FRESHMAN YEAR

First Semester (Fall)				Second Semester (Spring)			
		Course				Course	
CH	101	General Chemistry I	4	CH	102	General Chemistry II	4
EC	110	Prin Microecon	3	EN	102	English Comp II	3
EN	101	English Comp	3	GES	132	Found Engr II	2
GES	131	Found Engr I	3	MATH	126	Calculus II	4
MATH	125	Calculus I	4	PH	105	Gen. Physics I w/Cal I	4
		Semester Credit Hours	17			Semester Credit Hours	17

SOPHOMORE YEAR

First Semester (Fall)				Second Semester (Spring)			
		Course				Course	
AEM	201	Statics	3	AEM	250	Mech of Materials I	3
CE	260	Surveying	3	AEM	251	Mech of Materials lab	1
DR	133	AutoCAD for Engineers	2	AEM	264	Dynamics	3
MATH	227	Calculus III	4	CE	262	CE Materials	3
PH	106	Gen. Physics II/w Cal II	4	MATH	238	Appl Dif Eq I	3
				COM	123	Public Speaking	3
		Semester Credit Hours	16			Semester Credit Hours	16

JUNIOR YEAR

First Semester (Fall)				Second Semester (Spring)			
		Course				Course	
AEM	311	Fluid Mechanics	3	CE	333	Structural Steel Design I	3
AEM	312	Fluid Mechanics Lab	1	CE	420	Intro to Environ Eng	3
CE	331	Struc Analysis I	4	CE	421	Environ Chemistry Lab	1
CE	340	Geotech Engr I	4	CE	450	Highway Design	3
CE	342	Geotech Engr Lab	1	CE	478	Water Resources Eng	3
		History/Social Behavior	3			History/Social Behavior	3
		Semester Credit Hours	16			Semester Credit Hours	16

SENIOR YEAR

First Semester (Fall)				Second Semester (Spring)			
		Course				Course	
CE	433	Rein Concrete Struc I	3	CE	401	CE Design Project	4
ECE	320	Fund of Electrical Eng	3	CE	467	Con Methods & Estimate	3
		Statistics Elective	3	IE	203	Engineering Economics	3
		CE Elective	3			Technical Elective	3
		CE Elective	3			Human, Lit, or Fine Art	3
		Human, Lit, or Fine Art	3				
		Semester Credit Hours	18			Semester Credit Hours	16

Total Program Credit Hours: 132

Following is the curriculum at the University of Alabama effective fall 2010 (post-BOK).

FRESHMAN YEAR

First Semester (Fall)				Second Semester (Spring)			
		Course				Course	
EN	101	English Comp	3	EN	102	English Comp II	3
ENGR	111	Engineering the Future	1	ENGR	141	Eng Concept & Design II	1
ENGR	131	Eng Concept & Design I	1	ENGR	171	Large-Scale Eng Graphics	1
ENGR	151	Fund of Eng Graphics	1	MATH	126	Calculus II	4
MATH	125	Calculus I	4	PH	105	Gen. Physics I w/Cal I	4
CE	121	Intro to CCE Eng	1			History/Social Behavior	3
		App Natural Science	4				
		Semester Credit Hours	15			Semester Credit Hours	16

SOPHOMORE YEAR

First Semester (Fall)				Second Semester (Spring)			
		Course				Course	
AEM	201	Statics	3	CE	262	CE Materials	3
CE	260	Surveying	2	AEM	250	Mech of Materials I	3
MATH	227	Calculus III	4	AEM	264	Dynamics	3
CH	101	General Chemistry I	4	MATH	238	Appl Dif Eq I	3
		Human, Lit, or Fine Art	3			Gen Chem II/Gen Phy w/ Calc II	4
		Semester Credit Hours	16			Semester Credit Hours	16

JUNIOR YEAR

First Semester (Fall)				Second Semester (Spring)			
		Course				Course	
AEM	311	Fluid Mechanics	3	CE	366	Intro to Construction Eng	3
CE	331	Intro to Structural Eng	3	CE	320	Intro to Environ Eng	3
CE	340	Geotech Engr I	4	CE	378	Water Resources Eng	3
CE	350	Intro to Trans Eng	3			Fund Elec Eng/Ther Eng Survey	3
		History/Social Behavior	3			History/Social Behavior	3
		Semester Credit Hours	16			Semester Credit Hours	15

SENIOR YEAR

First Semester (Fall)				Second Semester (Spring)			
		Course				Course	
		Senior Plan of Study	3	CE	401/ 403	CE Proj Site Dev/CE Proj Buil Des	4
		Senior Plan of Study	3			Senior Plan of Study	3
		Senior Plan of Study	3			Senior Plan of Study	3
GES	255	Engineering Statistics	3			Senior Plan of Study	3
COM	123	Public Speaking	3			Human, Lit, or Fine Art	3
		Semester Credit Hours	15			Semester Credit Hours	16

Total Program Credit Hours: 125

Appendix II—Civil Engineering Curricula at the University of Arkansas

Following is the curriculum at the University of Arkansas as it was implemented in 2007

Freshman Year

First Semester (Fall)	Course	Hrs	Second Semester (Spring)	Course	Hrs
ENGL 1013	Composition I	3	ENGL 1023	Technical Composition II	3
MATH 2554	Calculus I	4		Freshman Science Elective	4
CHEM 1113	University Chemistry I	3		Freshman Science Elective Laboratory	0
PHYS 2054	University Physics I	4	MATH 2564	Calculus II	4
PHYS 2054L	University Physics Laboratory	0	HIST( )	HIST 2003, HIST 2013, or PLSC 2003	3
GENG 1111	Introduction to Engineering	1	GENG 1121	Introduction to Engineering II	1
	Semester Credit Hours	**15**		**Semester Credit Hours**	**15**

Sophomore Year

First Semester (Fall)	Course	Hrs	Second Semester (Spring)	Course	Hrs
MATH 2574	Calculus III	4	CVEG 2113	Structural Materials	3
MEEG 2003	Statics	3	INEG 3133	Engineering Statistics	3
GNEG 1122	Introduction to CAD	2	MATH 3404	Differential Equations	4
	Fine Arts Elective	3	GEOL 3002	Geology for Engineers	2
CVEG 2053	Surveying Systems	3		Humanities/Social Science	3
CVEG 2051L	Surveying systems Laboratory	1	MEEG 3013	Mechanics of Materials	3
	Semester Credit Hours	**16**		**Semester Credit Hours**	**18**

Junior Year

First Semester (Fall)	Course	Hrs	Second Semester (Spring)	Course	Hrs
CVEG 3304	Structural Analysis	4	CVEG 3022	Public Works Economics	2
CVEG 3133	Soil Mechanics	3	CVEG 3223	Hydrology	3
	Science Elective	4	CVEG 3243	Environmental Engineering	3
CVEG 3213	Hydraulics	3	CVEG 4313	Structural Steel Design	3
CVEG 3413	Transportation Engineering	3		Social Science Elective	3
				Engineering elective	3
	Semester Credit Hours	**17**		**Semester Credit Hours**	**17**

Senior Year

First Semester (Fall)	Course	Hrs	Second Semester (Spring)	Course	Hrs
CVEG 4143	Foundation Engineering	3	CVEG 4243	Environmental Engineering Design	3
CVEG 4433	Transportation Pvmts and Materials	3	CVEG 4513	Construction Management	3
CVEG 4852	Professional Practice Issues	2	CVEG ( )	Civil Engineering Electives	6
CVEG 4303	Reinforced Concrete Design I	3	CVEG ( )	Civil Engineering Design Elective	1
	Social Science Elective	3		Social Science Elective	3
CVEG ( )	Civil Engineering Design Elective	1			
	Engineering Design Elective	3		**Semester Credit Hours**	**16**
	Semester Credit Hours	**18**			

Total Program Credit Hours: 132

Following is the curriculum at the University of Arkansas to be implemented in 2012

Freshman Year

First Semester (Fall)

Course		Hrs
ENGL 1013	Composition I	3
MATH 2554	Calculus I	4
CHEM 1113	University Chemistry for Engineers I	3
PHYS 2054	University Physics I	4
PHYS 2054L	University Physics Laboratory	0
GENG 1111	Introduction to Engineering	1
	Semester Credit Hours	**15**

Second Semester (Spring)

Course		Hrs
ENGL 1023	Technical Composition II	3
	Freshman Science Elective	4
	Freshman Science Elective Laboratory	0
MATH 2564	Calculus II	4
HIST( )	HIST 2003, HIST 2013, or PLSC 2003	3
GENG 1121	Introduction to Engineering II	1
	Semester Credit Hours	**15**

Sophomore Year

First Semester (Fall)

Course		Hrs
MATH 3083	Linear Algebra	3
CVEG 2014	Civil Engineering Mechanics	4
CVEG 2011L	Civil Engineering Mechanics Laboratory	1
	Fine Arts Elective	3
CVEG 2053	Surveying Systems	3
CVEG 2051L	Surveying systems Laboratory	1
	Semester Credit Hours	**15**

Second Semester (Spring)

Course		Hrs
CVEG 2113	Structural Materials	3
INEG 2313	Applied Probability & Statistics for Engineers I	3
MATH 3404	Differential Equations	4
GEOL 1113	General Geology	3
GEOL 1111L	General Geology Laboratory	1
CVEG 2002	Introduction to Plans and CADD	2
	Semester Credit Hours	**16**

Junior Year

First Semester (Fall)

Course		Hrs
CVEG 3304	Structural Analysis	4
CVEG 3133	Soil Mechanics	3
CVEG 3131L	Soil Mechanics Laboratory	1
CVEG 3213	Hydraulics	3
CVEG 3413	Transportation Engineering	3
	Humanities Elective	3
	Semester Credit Hours	**17**

Second Semester (Spring)

Course		Hrs
INEG 2413	Engineering Economic Analysis	3
CVEG 3223	Hydrology	3
CVEG 3243	Environmental Engineering	3
CVEG 4303	Reinforced Concrete Design I	3
	Social Science Elective	3
	Engineering elective	3
	Semester Credit Hours	**18**

Senior Year

First Semester (Fall)

Course		Hrs
CVEG 4143	Foundation Engineering	3
CVEG 4423	Geometric Design	3
CVEG 4851	Professional Practice Issues	1
CVEG ( )	Civil Engineering Elective	3
	Social Science Elective	3
CVEG ( )	Civil Engineering Design Elective	2
	Semester Credit Hours	**15**

Second Semester (Spring)

Course		Hrs
CVEG 4243	Environmental Engineering Design	3
CVEG 4513	Construction Management	3
CVEG ( )	Civil Engineering Electives	6
CVEG ( )	Civil Engineering Design Elective	2
	Social Science Elective	3
	Semester Credit Hours	**17**

Total Program Credit Hours: 128

Appendix III—Civil Engineering Curricula at The University of Texas at Tyler

Following is the curriculum that was implemented in 2005 at the time of BOK1.

Freshman Year

First Semester (Fall)

Course		Hrs
UNIV 1300	Freshman Seminar	3
ENGL 1301	Grammar and Composition I	3
MATH 2413	Calculus I	4
CHEM 1311	General Chemistry	3
CHEM 1111	Chemistry I Laboratory	1
ENGR 1200	Engineering Methods	2
	Semester Credit Hours	**16**

Second Semester (Spring)

Course		Hrs
CENG 1201	Civil Engineering Graphics	2
ENGL 1302	Grammar and Composition II	3
MATH 2414	Calculus II	4
PHYS 2325	University Physics I	3
PHYS 2125	Physics I Laboratory	1
	Visual and Performing Arts Elective	3
	Semester Credit Hours	**16**

Sophomore Year

First Semester (Fall)

Course		Hrs
CENG 2336	Geomatics	3
CENG 2331	Civil & Environmental Engineering Computing	3
ENGR 2301	Engineering Mechanics—Statics	3
MATH 3404	Multi-Variable Calculus	4
PHYS 2326	University Physics II	3
PHYS 2126	Physics II Laboratory	1
	Semester Credit Hours	**17**

Second Semester (Spring)

Course		Hrs
CENG 2253	Civil Engineering Measurement	2
MENG 3306	Mechanics of Materials	3
MATH 3305	Differential Equations	3
ENGR 2302	Engineering Mechanics—Dynamics	3
ECON 2302	Microeconomics	3
PHIL 2306	Introduction to Ethics	3
	Semester Credit Hours	**17**

Junior Year

First Semester (Fall)

Course		Hrs
CENG 3338	Civil Engineering Materials	3
MENG 3310	Fluid Mechanics	3
ENGR 3301	Probability & Statistics for Engineers	3
ENGR 4306	Engineering Economics	3
	Additional Science Elective	3
	Semester Credit Hours	**15**

Second Semester (Spring)

Course		Hrs
CENG 3361	Applied Engineering Hydrology	3
CENG 3351	Transportation Engineering Systems	3
CENG 3333	Building Codes, Contracts and Specifications	3
CENG 3336	Soil Mechanics	3
CENG 3325	Structural Analysis	3
	Semester Credit Hours	**15**

Senior Year

First Semester (Fall)

Course		Hrs
CENG 4351	Transp. & Regional Planning w/Laboratory	3
CENG ( )	Structural Design Elective	3
CENG ( )	Construction Engineering Elective	3
CENG 4115	Senior Design I	1
HIST 1301	United States History I	3
POLS 2305	Introduction to American Government	3
	Semester Credit Hours	**16**

Second Semester (Spring)

Course		Hrs
CENG ( )	Engineering Design Elective	3
CENG 4315	Senior Design II	3
HIST 1302	United States History II	3
POLS 2306	Introduction to Texas Politics	3
ENGR 4109	Senior Seminar	1
	World or European Literature Elective	3
	Semester Credit Hours	**16**

Total Program Credit Hours: 128

Following is the curriculum as it exists today as a result of BOK2.

Freshman Year

First Semester (Fall)

	Course	Hrs
POLS 2306	Introduction to Texas Politics	3
ENGL 1301	Grammar and Composition I	3
MATH 2413	Calculus I	4
CHEM 1311	General Chemistry	3
CHEM 1111	Chemistry I Laboratory	1
ENGR 1201	Introduction to Engineering	2
	Semester Credit Hours	**16**

Second Semester (Spring)

	Course	Hrs
ENGR 1204	Engineering Graphics	2
ENGL 1302	Grammar and Composition II	3
MATH 2414	Calculus II	4
PHYS 2325	University Physics I	3
PHYS 2125	Physics I Laboratory	1
	Visual and Performing Arts Elective	3
	Semester Credit Hours	**16**

Sophomore Year

First Semester (Fall)

	Course	Hrs
POLS 2305	Introduction to American Government	3
CENG 2336	Geomatics	3
ENGR 2301	Engineering Mechanics—Statics	3
MATH 3404	Multi-Variable Calculus	4
PHYS 2326	University Physics II	3
PHYS 2126	Physics II Laboratory	1
	Semester Credit Hours	**17**

Second Semester (Spring)

	Course	Hrs
HIST 1301	United States History I	3
MENG 3306	Mechanics of Materials	3
MATH 3305	Differential Equations	3
ENGR 2302	Engineering Mechanics—Dynamics	3
ECON 2302	Microeconomics	3
PHIL 2306	Introduction to Ethics	3
	Semester Credit Hours	**18**

Junior Year

First Semester (Fall)

	Course	Hrs
CENG 3434	Civil Engr Materials, Codes, & Specifications	4
MENG 3310	Fluid Mechanics	3
MATH 3351	Probability & Statistics for Engineers	3
CENG 4339	Civil Engineering Construction Management	3
	Additional Science Elective	3
	Semester Credit Hours	**16**

Second Semester (Spring)

	Course	Hrs
CENG 3361	Applied Engineering Hydrology	3
CENG 3351	Transportation Engineering Systems	3
CENG 3371	Introduction to Environmental Engineering	3
CENG 3336	Soil Mechanics	3
CENG 3325	Structural Analysis	3
	Semester Credit Hours	**15**

Senior Year

First Semester (Fall)

	Course	Hrs
CENG ( )	2 of CENG 4351, CENG 4381, CENG 4371	6
CENG 4412	Steel and Concrete Design	4
CENG 4115	Senior Design I	1
CENG ( )	Civil Engineering Technical Elective	3
ENGR 4109	Senior Seminar	1
	Semester Credit Hours	**15**

Second Semester (Spring)

	Course	Hrs
	Technical Elective	3
CENG 4315	Senior Design II	3
HIST 1302	United States History II	3
CENG 4341	Leadership, Business & Asset Management	3
	World or European Literature Elective	3
	Semester Credit Hours	**15**

Total Program Credit Hours: 128

Chapter 7

Strengthening Experiential Guidelines

Monte L. Phillips, Ph.D., P.E., F.ASCE, F.NSPE, F.NAFE, ***University of North Dakota***

Forrest M. Holly, Ph.D., P.E., ***University of Iowa***

Originally published as "The Raise the Bar Initiative: Charting the Future by Understanding the Path to the Prsent—Experiential Guidelines," in *Proceedings of the 2012 Conference of the American Society for Engineering Education*, June 2012.

The "Raise the Bar" Initiative: Charting the Future Through Strengthened Experiential Guidelines

Abstract

The purpose of this paper is to provide the engineering education community with a summary of ASCE's Body of Knowledge (BOK) Experiential Fulfillment Committee's (BOKExFC) initial work to improve the pre-licensure attainment of experience outcomes for engineering interns. ASCE's "experiential initiative" began in 2007 and ultimately led to the development of the *Guidelines for Attainment of Experiential Outcomes* for the outcomes with experiential expectations contained in the second edition of the civil engineering BOK. This paper provides a summary of the BOKExFC activities and emphasizes the guidance for engineering interns, supervisors, and mentors for documenting, validating, and reporting experience activities during the pre-licensure state of an intern's career.

Introduction

In 1995 at the American Society of Civil Engineers (ASCE) Civil Engineering Education Conference, educational and professional leaders in the civil engineering community in the United States began efforts to reform civil engineering education. As a result of this initiative, ASCE Policy Statement 465—Academic Prerequisites for Licensure and Professional Practice was passed in 1998. ASCE Policy 465 calls for an increase in the educational requirements beyond the baccalaureate degree and the adoption of appropriate experience requirements as a prerequisite for the professional practice of civil engineer, i.e., ASCE's "Raise the Bar" initiative, or *Raise the Bar* in the remainder of this paper. The Committee on Academic Prerequisites for Professional Practice (CAP^3) was constituted as an ASCE Board-level committee and charged with implementation of the *Raise the Bar* initiative.

The initial step in response to this charge was the formation of the Body of Knowledge Committee in May 2002. It was charged with defining the knowledge, skills, and attitudes needed to enter the practice of civil engineering at the professional level, i.e., licensure. The BOK committee published the first edition of the *Civil Engineering Body of Knowledge for the 21st Century* (BOK1[1]) in February 2004; a revised (second) edition was published in February 2008 (BOK2[2]). The BOK2 is a comprehensive list of 24 outcomes divided into three outcome categories: foundational, technical, and professional. The BOK2 outcomes have the desired level of achievement defined according to Bloom's Taxonomy for the cognitive domain[3]. The BOK2 has recommended outcome achievement targets for each stage of the fulfillment pathway: the baccalaureate degree (B), post-baccalaureate formal education (M/30), and pre-licensure experience (E) (see Figure 1).

Detailed implementation guidelines are included in the second edition of the *Civil Engineering Body of Knowledge for the 21st Century (BOK2*[2]); see www.asce.org/raisethebar/reports. Policy 465 and BOK2 are aligned with the National Academy of Engineering's *The Engineer of 2020: Visions of Engineering in the New Century*[4] and ASCE's *The Vision for Civil Engineering 2025*[5].

At the request of CAP^3, an exploratory ASCE Experience Committee[6] was formed in early 2007 and directed to focus on the BOK2 outcomes with pre-licensure experience expectations. The stated expectation in the BOK2 is that "it consists of specific outcomes which must be achieved by all civil engineers prior to licensure." The basic premise underlying the exploratory committee's evaluation, critique, and subsequent recommendations is that the licensing process is the logical, perhaps the only, pathway for enforcing and validating the attainment of the Body of Knowledge as a prerequisite for entry into the professional practice of engineering. Consequently, the exploratory committee addressed its charges from the licensure perspective or context and focused on the outcomes in the BOK2 with experience expectations.

Still, irrespective of licensure considerations, the exploratory committee felt that in striving to attain the educational and experiential outcomes of the Body of Knowledge, the graduate civil engineer is investing in a successful and rewarding career in which progression is recognized through licensure and promotion to positions of increasing responsibility.

The exploratory committee's conclusions acknowledged that accumulation and validation of acceptable experience are common requirements for entry into professional practice in many professions, including engineering. But in the United States, engineering experience requirements and expectations are poorly articulated, non-uniform across licensing jurisdictions, and generally lacking in structure and rigor. There is little if any resonance between the strong ASCE experiential outcomes and the current weak procedures for validating pre-licensure experience existing in the various licensing jurisdictions across the country. During presentations of *Raise the Bar* and its educational elements to engineer practitioner groups around the country, an issue often raised from the floor was that, while increasing educational expectations may be justified, the profession also needed stronger experience expectations prior to licensure. The efforts of CAP^3 to strengthen experience expectations as described in this paper directly address that concern from practitioners and employers.

Included in the exploratory committee recommendations[4] was the formation of a Body of Knowledge Experiential Fulfillment Committee with strong representation of practitioners from consulting, industrial, and agency/government environments. Recommended charges to this new committee included:

- Develop a stand-alone "Guidelines Document" using the 15 outcomes in the BOK2 with experiential expectations as a basis to be used by civil engineering interns and their mentor/supervisors during the pre-licensure state of the intern's career. The suggested goal is to provide a resource document that interns will find both useful and user friendly in documenting, validating, and reporting their pre-licensure experience activities.

The Body of Knowledge Experiential Fulfillment Committee was constituted in the spring 2009. The efforts of this committee serve as a basis for this paper. The complete report of the committee is available at www.asce.org/raisethebar/reports .

The Civil Engineering Body of Knowledge—An Overview

A significant contribution to the second edition of the BOK (BOK2) was the adoption of Bloom's taxonomy as a mechanism to link body of knowledge outcomes to actual learning and achievement.

Bloom's taxonomy is based on three distinct domains—the cognitive, the affective, and the psychomotor. The cognitive domain deals with the recall or recognition of knowledge and the development of intellectual abilities and skills. The affective domain involves interest, attitudes, and values. The psychomotor domain relates to manipulative or motor-skills. The cognitive domain has the most direct application here because it addresses many of the conventional learning outcomes associated with engineering and is aligned well with the engineering process.

The cognitive domain within Bloom's Taxonomy has six defined levels of achievement (LOA):

> Level 1—Knowledge: simple recollection of previously learned material, which may range from specific facts to complete theories.
>
> Level 2—Comprehension: explaining or describing the meaning of learned material, including perhaps estimating possible future trends.
>
> Level 3—Application: use learned material in new situations to solve new problems.
>
> Level 4—Analysis: breaking down learned and new material into basic component parts or principles, including defining relationships between parts.
>
> Level 5—Synthesis: creating new knowledge or designing new systems, either uniquely or putting together existing components to form a new whole.
>
> Level 6—Evaluation: judging the relative merit or value of material for a defined purpose, including examining potential impacts and ramifications.

Further information and discussion of Bloom's Taxonomy can be found in Appendices F and G of BOK2 (www.asce.org/raisethebar/reports).

The BOK2 Outcome Rubric, developed using Bloom's Taxonomy, is graphically presented in Figure 1. This is a simple graphical representation of the recommended level of achievement that an individual must demonstrate for each outcome to enter into the practice of civil engineering at the professional level. Figure 1 depicts the level of achievement to be fulfilled through the bachelor's degree (B), the master's degree or equivalent (M/30), and pre-licensure experience (E) for each outcome. This paper is focused on recommendations for achieving, documenting, validating, and reporting experience activities during the pre-licensure stage (E) of an engineering intern's career.

ASCE BOK Experiential Fulfillment Committee (BOKExFC) – —An Overview

An important objective in forming the BOKExFC was to populate the committee with a diverse group of civil engineering practitioners from a variety of work environments and new to the CAP^3 organizational structure. Applications for committee membership were solicited in a variety of ASCE publications. Thirty applicants were selected to attend a one-day face-to-face workshop in January of 2009. The objectives of the workshop were to first educate the participants on the BOKExFC committee charges and expectations of committee membership, and secondly to evaluate the potential of the prospective committee members to contribute to the committee's efforts. Following the workshop, those attending were asked to confirm their interest in and willingness to serve on the committee. From those attending the workshop, nine were selected for full committee membership plus a chair and vice chair. Fourteen requested to be corresponding members and were invited to participate in all committee conference calls. In addition to three face-to-face full committee meetings, 25 conference calls were held over a two-year period at two- to four-week intervals. The committee leadership met face-to-face to draft the BOKExFC Final Report and finalize the "Guidelines Document," referred to as the *Guidelines* in the remainder of this paper. A detailed documentation of the committee activities can be found in Appendix C of the final report.

		LEVEL OF ACHIEVEMENT					
OUTCOME #	OUTCOME TITLE	1	2	3	4	5	6
1	Mathematics	B	B	B			
2	Natural Sciences	B	B	B			
3	Humanities	B	B	B			
4	Social Sciences	B	B	B			
5	Material Science	B	B	B			
6	Mechanics	B	B	B	B		
7	Experiments	B	B	B	B	M/30	
8	Prob Recog/Solving	B	B	B	M/30		
9	Design	B	B	B	B	B	E
10	Sustainability	B	B	B	E		
11	Contemp Issues/History	B	B	B	E		
12	Risk & Uncertainty	B	B	B	E		
13	Proj Management	B	B	B	E		
14	Breadth in CE	B	B	B	B		
15	Tech Specialization	B	M/30	M/30	M/30	M/30	E
16	Communication	B	B	B	B	E	
17	Public Policy	B	B	E			
18	Business & Public Admin	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	Lifelong Learning	B	B	B	E	E	
24	Professional & Ethics	B	B	B	B	E	E

Figure 1: Graphical Representation of the BOK2 Outcome Rubric

Committee charges included the following:

Critique and Revise the BOK2 Experiential Outcomes

- Recast the BOK2 experiential outcomes into a form applicable to civil engineers in various working environments.
- Generalize to other engineering disciplines where possible.
- If appropriate, propose additional outcomes to accommodate the career paths of civil engineers.

Develop a stand-alone set of experience guidelines to be followed by a civil engineer intern during his or her pre-licensure career.

- These guidelines should include not only the substantive elements of the experiential outcomes, but also provisions for reporting, mentorship, assessment, and validation of the experience elements.

This paper focuses on the above two charges, resulting in the *Guidelines*. As used in the *Guidelines*, the term "Engineer Intern," or EI, is a graduate engineer in the early stages of an engineering career and who has passed the Fundamentals of Engineering (FE) examination as the first step toward licensure.

Development of the *Guidelines*

Of the 24 BOK2 outcomes in Figure 1 above, nine should be fulfilled entirely through the formal educational process. These nine outcomes are designated by a "B" or "M/30" (Outcomes 1–8 and 14.)

The *Guidelines* focuses on the remaining fifteen that are referred to as the **experiential outcomes**. These outcomes, designated by an "E" in Figure 1, are summarized in Table 1 below:

Outcome 9	Design	Outcome 18	Business and Public Administration
Outcome 10	Sustainability	Outcome 19	Globalization
Outcome 11	Impacts of contemporary issues & historical perspectives	Outcome 20	Leadership
Outcome 12	Risk and Uncertainty	Outcome 21	Teamwork
Outcome 13	Project Management	Outcome 22	Professional Values and Attitudes
Outcome 15	Technical Specialization	Outcome 23	Lifelong Learning
Outcome 16	Communication	Outcome 24	Professional and Ethical Responsibility
Outcome 17	Public Policy		

Table 1: Experiential Outcomes

The EI is expected to attain the outcomes through professional work experiences whenever possible. However, EIs in some working environments may not have the opportunity to attain certain outcomes through on-the-job experience. In such cases, EIs may attain the outcome during the first few years of their career period through other experiences, such as professional training programs and/or community/civic activities as suggested in some of the illustrative experiences included in the *Guidelines.*

The fifteen experiential outcomes are given roughly equal consideration and attention in the *Guidelines*. However, the importance of the various outcomes, and the time and attention devoted to attaining each, may vary significantly from one civil-engineering work environment to another. Examples of differing work environments include design offices, facility management, academe, regulatory agencies, etc. While opportunities for attaining outcomes such as Outcomes 20 to 24 in Figure 1 may be relatively common across all work environments, opportunities for attaining others such as 9 (Design) and 13 (Project Management) maybe quite different from one environment to another. Nonetheless, it is the expectation of the civil engineering profession that the EI will demonstrate attainment of **all** of the outcomes prior to entry into the practice of civil engineering at a professional level, whatever their work environment(s) may have been during the early stages of their career. The *Guidelines* attempt to recognize these differences in offering multiple example pathways for attainment of all the experiential outcomes.

Experiential outcome attainment is a self-directed responsibility of the EI, achieved in close consultation with supervisors, mentors and licensing boards. A mentor (who could also be a supervisor) is a colleague or associate whose experience in the subject area of an outcome enables them to guide and counsel the EI in attaining the outcome, and to validate the EI's attainment.

An essential expectation in the attainment of experiential outcomes is the notion of progression in responsibility during an EI's early career. **Progressive experience** involves successive and continued progress from initial work of simpler character to professional work of greater complexity with a higher degree of responsibility. Such experience should demonstrate to the licensing jurisdiction or other reviewing authorities the capacity of the engineering intern to review the applications of engineering principles by others and to assume responsibility for engineering work of a professional character at a level that will protect the public health, safety and welfare. The EI's experience in attaining a particular experiential outcome may not, in itself, reflect progressive experience. However, attainment of the ensemble of fifteen experiential outcomes must demonstrate progressive experience.

Responsibilities of the Engineer Intern

The fulfillment and demonstration of attainment of the experiential outcomes is the responsibility of the EI. Throughout various work environments and project assignments, and possible multiple employments, the EI should maintain ownership and assume continuity of his or her efforts to achieve and document progressive experience in the first few years of their career.

The EI should prepare and frequently update a written plan for demonstrating the attainment of all experiential outcomes. The plan should be a dynamic document, periodically revisited and revised as necessary, and reviewed with mentors and, as appropriate, with their licensing jurisdiction. The plan should ensure development of a portfolio that documents experience and demonstrates achievement and validation of the experiential outcomes.

The EI is also responsible for developing relationships with mentors who can provide guidance, insight, and tutelage through face-to-face meetings and review of their work.

Responsibility of Supervisors and Other Mentors

Assessment and validation of the EI's attaining the experiential outcomes will require close involvement of professional mentors. For technical outcomes, supervisors and mentors are typically licensed Professional Engineers (a mentor need not be in active practice). For some of the "professional practice" outcomes, it may be appropriate for the EI to enlist and engage a non-engineer mentor with expertise in those relevant outcomes. Guidance for finding mentors from outside the engineering workplace, when appropriate, is provided in Appendix B of the *Guidelines.*

The mentor should:

- Be familiar with the expectation of the Civil Engineering Body of Knowledge, in particular with regard to the experiential outcomes.
- Provide guidance, insight, and tutelage to the EI through face-to-face meetings and review of the EI's work products, with specific reference to one or more experiential outcomes and their associated guidelines, and be mindful of the expectation of progression in professional responsibilities.
- Be cognizant of jurisdictional licensing requirements and the EI's requirement to demonstrate attainment of the experiential outcomes, and enable the EI to tailor their work assignment to this end.
- Monitor the EI's progression in professional responsibility and provide guidance to ensure that the EI's activities contribute to credible progressive experience.
- Provide written statements of assessment and validation for the EI's experience portfolio.
- At regular intervals, review with the EI the plan for attainment of the experiential outcomes and guide the EI in updating the plan to reflect changes in activities and the need for other types of outcome attainment.
- Validate, where appropriate, the EI's attainment of an outcome through appropriate activities and experiences.

Appendix C of the *Guidelines* contains expanded guidelines for supervisors and mentors.
Due to the diversity and complexity of some of the experiential outcomes, it may be necessary for an EI to engage and consult a number of different mentors, even for the same experiential outcome. Mentors should advise and assist the EI in finding the appropriate expertise to validate attainment of all experiential outcomes.

Guidelines for Demonstrating Attainment of Experiential Outcomes

Procedures for attainment of the fifteen experiential outcomes are outlined in the *Guidelines.* They are based on the notions of outcomes, activities, and illustrative experiences as defined below:

- **Outcomes** – Statements that describe what EIs are expected to know and be able to do by the time of entry into the practice of civil engineering at the professional level. Outcomes define the knowledge, skills, and attitudes that individuals acquire through appropriate formal education and early-career experience.
    - **Activities** –Work efforts from a variety of engineering environments that could provide a pathway for partial or full attainment of an outcome.
        - **Illustrative Experiences** – Documentable examples that demonstrate completion of an activity.

Completion of at least one **activity** is required to demonstrate attainment of an outcome.

In the *Guidelines,* each experiential **outcome** includes a summary narrative description. Full statements of the educational and experiential components of each outcome are in Appendix J of the BOK2. Each outcome statement is followed by a list of possible **activities** that the EI could pursue to demonstrate attainment. For each activity a brief set of **illustrative experiences** demonstrates the kinds of engineering experiences that would be supportive of the activity.

Although the activities and experiences included in the *Guidelines* are intended to capture the broad diversity of engineering working environments and communicate the expected level of involvement, they are presented only as an **illustrative methodology for attainment.** They should serve as guidance to the EI in pursuing these or other similar activities and experiences reflecting the opportunities and constraints of their particular work environment, mentor interests, and possible current and future licensure board expectations. There is no expectation that the outcomes be attained in the order in which they are presented in the *Guidelines.*

Experiential Outcomes Attainment Portfolio

The *Guidelines* have been developed to assist the EI in understanding the necessary experience needed to attain the prescribed Body of Knowledge (outcomes). The EI should become familiar with and understand the *Guidelines* and suggested reporting forms (See Figures 2 and 3). The reporting of progressive experience should include a narrative describing the activities completed for each outcome. These narratives with validating signatures should be retained for possible future review by an appropriate licensing authority. The *Guidelines* provide examples of various activities that, when completed, may assist the EI in demonstrating attainment of that particular outcome. Often more than one activity will be necessary to demonstrate satisfactory attainment. Illustrative experiences outlined for an activity are to demonstrate the type and extent of experience that would most likely qualify. The EI should have the mentor sign Form 1 when the relevant experiences or activities have been satisfactorily completed. When the EI gains sufficient progressive experience that demonstrates attainment of an outcome, a mentor should sign Form 2. An EI's experience portfolio should include completed Form(s) 1 and Form 2 for each of the fifteen outcomes with experiential expectations.

Example from *Guidelines*—Outcome 9: Design

Outcome 9 (Design) received a great deal of attention from the BOKExFC, for several reasons:

- Design experience is perhaps most closely aligned with the traditional experience expectations of licensing boards at present.
- Given the broad diversity of civil engineering work environments, attainment of the design outcome can follow quite different paths (e.g., design office vs. academe).
- The notion of education and experience in the engineering design concepts is fundamental to the engineering process, and is recognized as such by accreditation agencies as well as the licensure community.

The *Guidelines* material for the Design outcome is presented in Appendix A; the other 14 experiential outcomes have similar sections in the *Guidelines*. Note from Figure 1 that the BOK2 outcomes assign Bloom's achievement level 6 (Evaluation) to the experiential expectations of the design outcome. Appendix A also includes an example portfolio entry for this outcome.

Recommendations for Implementation of the *Guidelines*

The final report of the BOK Experiential Fulfillment Committee included recommendations for implementation of the *Guidelines:*

1. Publish the *Guidelines* on the ASCE web site and publicize its existence through internal member publications, newsletters, and announcements. This effort might include creation of a summary pamphlet providing an introductory overview of the *Guidelines.*

2. Host an ASCE workshop/colloquium, possibly as a webinar, to accompany initial publication of the *Guidelines.* The workshop would enable interested individuals to be introduced to the purpose and contents of the *Guidelines.* ASCE could establish a continuing on-line discussion board that allows participants to (1) provide feedback and ask questions about the *Guidelines* and (2) identify issues and provide recommendations for a future edition of the *Guidelines.*

3. Establish a new ASCE Experiential Guidelines Implementation Committee. Charges to the committee could include:

   - Identify the internal and external stakeholders for the *Guidelines* (possibly to include other engineering professional societies, ABET and NCEES).
   - Prepare and implement a plan to encourage EIs to use the *Guidelines.*
   - Prepare and implement a plan to encourage firms and organizations that employ engineers to incorporate the *Guidelines* in their professional development program for their EIs.
   - Prepare and implement a plan to evaluate the *Guidelines* with a test group of EIs and their mentors/supervisors. This testing would encompass a critical assessment and evaluation of (1) the activities and illustrate experiences associated with each experiential outcome and (2) the validation processes recommended in the *Guidelines.*

- Evaluate the rationale, benefits, and costs of establishing an ASCE "Body of Knowledge Experiential Fulfillment Certificate" program that would recognize an individual's attainment of the fifteen BOK2 outcomes with experiential expectations.

The BOKExFC focused primarily on the civil engineering profession, as charged. However with an eye to the future possible adoption of the outcomes and *Guidelines* by other engineering professions, it suggested editorial modifications to the Outcomes and phrasing in the *Guidelines* that would be inclusive of the other disciplines as *Raise the Bar* becomes established within civil engineering.

Final Thoughts

As stated in the Introduction, the value of this initiative goes well beyond licensure considerations. In striving to attain the educational and experiential outcomes of the Body of Knowledge, any graduate civil engineer is investing in a successful and rewarding career whose progression is recognized through promotion to positions of increasing responsibility, whether or not licensure is involved. This initiative's structured roadmap for growth in professional capabilities and responsibilities is of value to the engineer at whatever level it is adopted—from minimal and strictly individual self-directed progression at the entry level, through close mentoring, oversight, and documentation as shown for the Design outcome at the most aggressive level. There is no doubt that attainment of the experiential guidelines through this initiative demands special effort from both the EI and supervisors/mentors. Employers should value the opportunity to support their young engineers who wish to take charge of their career path in attaining the experiential outcomes in a structured manner. When and if outcome-based experience migrates into the licensure process, there may be resistance based on the additional effort required, compared to the present model. The BOKExFC believes that the enhanced competence and professionalism of young engineers is well worth whatever additional effort may be required.

Acknowledgments

This paper would not have been possible without the dedicated hard work of the exploratory ASCE Experience Committee and the members of the BOKExFC. The CAP^3 committee provided strong support and input throughout the experience. The authors wish to particularly express their gratitude to ASCE's Tom Lenox for his unfailing support, insight, and constructive perspective in assisting the various committees and providing suggestions during the preparation of this paper.

Bibliography

1. ASCE Body of Knowledge Committee of CAP^3. 2004. *Civil Engineering Body of Knowledge for the 21st Century: Preparing the Civil Engineer for the Future,* Reston, VA, January. (http://www.asce.org/raisethebar).

2. ASCE Body of Knowledge II Committee of CAP^3. 2008. *Civil Engineering Body of Knowledge for the 21st Century: Preparing the Civil Engineer for the Future,* Second Edition, Reston, VA, January. (http://www.asce.org/raisethebar).
3. Bloom. B.S., Englehart, M.D., Furst. E.J., Hill, W.H., and Krathwohl, D. 1956. *Taxonomy of Educational Objectives, the Classification of Educational Goals, Handbook I: Cognitive Domain.* David McKay, New York, NY.
4. National Academy of Engineering, *The Engineer of 2020: Visions of Engineering in the New Century* (2001)
5. ASCE *The Vision for Civil Engineering 2025* (2007)
6. ASCE Body of Knowledge Committee of CAP^3. 2007. *Final Report of the Experience Committee,* Reston, VA, July. (http://www.asce.org/raisethebar).

Appendix A

Outcome 9: Design

<u>The portion of the BOK envisioned to be achieved through pre-licensure experience is</u>
Level 6: ***Evaluate*** the design of a complex system, component, or process and **assess** compliance with customary standards of practice, user's and project's needs, and relevant constraints.

The post baccalaureate engineering design experience should include opportunities to employ many or all aspects of the design process, including problem definition, project and system planning, scoping, the design objective, the development of design options, standards, codes, economy, safety, constructability, operability, sustainability, and design evaluation. Experience at this level should include familiarity with interactions between planning, design, construction, and operations and should take into account design life-cycle assessment. The role of peer and senior review and of the design verification process in ensuring successful design should be emphasized to individuals at this level.

<u>Activity 9-1</u> ***Evaluate*** **a set of potential design conditions including potential problems, boundary conditions and performance expectations.**
Defining the scope and objectives of a design, and identifying the constraints and standards applicable to it are essential to the design process. Identifying the potential problems that will interfere with a design or hinder its implementation is a similarly critical part of the design process.

Illustrative Experiences

1. Assess a design scope of work for use in a project proposal or a request for proposals.
2. Recommend a set of design criteria and performance expectations, including applicable standards and boundary conditions.
3. Assess impacts associated with non-performance of a design or system, given the potential that design conditions may be exceeded or design constraints may be modified.

<u>Activity 9-2</u> ***Explain*** **and** ***defend*** **critical design decisions within peer groups, client representatives, and public forums.**

There are usually numerous ways to approach an engineering problem. Defining the appropriate approach to design is a critical part of the design process. This leads to evaluation of a variety of factors associated with the design and ultimately to selection of critical design decisions for the project based on these evaluations. Articulation of the rationale for design decisions is an essential part of the design process.

Illustrative Experiences

1. Explain the critical design decisions that are required to arrive at an appropriate design solution(s) for an engineering problem to those in responsible engineering charge of a project.
2. Summarize the design decisions reached for a project in a basis of design report or similar document, including reasons for selection and if applicable compliance with codes and standards.
3. Participate in explaining the design decisions to client representatives, including alternatives considered and reasons for decisions made including management of risks, costs, and meeting client objectives.
4. Recommend changes/revisions to a design as a result of feedback from client/regulatory/ public assessments and reviews.

<u>Activity 9-3</u> ***Recommend* a design solution for a specific set of conditions, problems, parameters, and/or boundary conditions. Design solutions include calculations, flow charts, reports, construction documents, specifications, software program design, and any other deliverable or verifiable documentation.**

A design solution is defined as any system, program, product or project plan, design, specifications, cost estimate and other outcomes that represent a detailed, analytical, and engineered description of a set of conditions or solution to a problem. Developing and applying such a solution to a complex set of conditions can involve planning and engineering activities of all sorts such as scheduling, cost estimating, budgeting, resource management, quality management, risk analysis, CAD, written narrative documentation, calculations, and other analyses.

Illustrative Experiences

1. Assess the life-cycle costs and expected performance of design alternatives for a design solution or product, quantitatively addressing capital or development costs as well as long term operation support and maintenance costs.
2. Recommend the best use of different manufacturing, development, materials or construction methods for a project or design solution including advantages and disadvantages regarding cost, constructability, consistency with other system elements, and sustainability.
3. Recommend appropriate specifications from practice/industry standards, governmental agency requirements, manufacturer's standards, or other source in the demonstration of a chosen design parameter.
4. Summarize knowledge regarding federal, state, and local standards and ordinances; owner/client requirements; construction means and methods; as well as available

materials, budget, and scheduling constraints to provide a design solution and produce construction documents.

<u>Activity 9-4</u> ***Evaluate* a design solution prepared by others for conformance with the owner's and the user's needs, utilizing objective parameters including, acceptable building codes, specifications, and other standards or regulations, or with regard to the initial set of design conditions or parameters.**

Examples of design solution(s) to similar design problems are commonly used by engineers to evaluate relevant design approaches. Each design solution must be analyzed in its entirety and/or broken down into various components to determine its functionality and applicability to the original's user's needs and those needs of the current project. It is through this process of evaluating the design solutions of others that the engineer may develop a greater understanding of the requirements and limitations of various project components and form a project approach to meet the design condition and/or parameters of the current project.

Illustrative Experiences

1. Assess components of the project that meet or do not meet the design conditions of the project. (e. g. building codes, regulations, sustainability, globalization, etc.)
2. Compare areas of the design solution that appear to have either excessive, appropriate or minimal associated safety factors and/or risks.
3. Appraise the constructability and cost of the design solution.
4. Assess the appropriateness of the design solution in comparison to the initial set of design conditions or parameters.

<u>Activity 9-5</u> ***Evaluate* the compromises that must be made among competing design parameters using rational approaches, and considering codes, technical papers, planning documents, statutes and regulations, permits and mitigation, specifications, and other standards.**

Compromises must be made between competing design parameters of the element or system that is being designed. A common example is life-cycle cost versus first cost. These compromises must be made in order to create a design that balances the goals of the project and the desires of the client. These compromises can be accomplished in many ways.

Illustrative Experiences

1. Evaluate the life-cycle costs and performance of design alternatives for a project or product, quantitatively addressing both capital or development costs and long-term operation (support) and maintenance and serviceability costs.
2. Evaluate the use of different manufacturing, development, materials or construction methods for a design including advantages/disadvantages in cost, availability,

constructability, consistency with other system elements, and sustainability.
3. Compare the appropriate factor of safety or performance assurance measure of a system being designed, based on relevant factors and appropriate assumption of risk.
4. Evaluate appropriate, established and/or required code(s), regulatory requirement, statutes and permits, planning documents, practice manuals, or other established standard in the determination of appropriate design parameter for a project.
5. Evaluate appropriate specifications from practice/industry standards, governmental agency requirements, manufacturer's standards, or other sources in the demonstration of a chosen design parameter.

Portfolio Example for Outcome 9 - Design

Now what follows is a detailed example of how Marilyn Johnson, EI, completed Forms 1 and 2 to document attainment of Outcome 9 – Design. The completed sample forms in Figures A.1, A.2, and A.3 below reflect the following scenario.

John Smith, a project engineer at Riverplace Engineering Corp., supervised Ms. Johnson, and from August 2006 through January 2009 she acquired two relevant design experiences. John Smith has provided a statement to that effect on a Form 1 (See Figure A.1). Marilyn was then supervised by Bill Jackson of Jackson and Associates and acquired an additional significant design experience during the period February 2009 through March 2010. Bill Jackson attests to this in a second Form 1 (See Figure A.2). Note that documentation for each of the engineering experiences includes attachments to the respective Form 1. Finally, Bill Jackson has also summarized his conclusion that Marilyn has attained the design outcome as described in the *Guidelines*. His validation of outcome attainment is summarized on Form 2 (See Figure A.3).

Similar documentation would be developed by the EI and his or her mentors and supervisors for each experiential outcome. Some may only require Form 1 and Form 2 statements by one supervisor and/or mentor.

FORM 1
List of Relevant Experiences

Engineer Intern: **Marilyn Johnson**

Use this form to identify ONE OR MORE relevant experiences relating to ONE OUTCOME verifiable by ONE supervisor or other mentor.
Fill in only yellow and blue highlighted blocks. Blue highlighted experience description blocks will expand to accommodate text as needed.

Outcome	Relevant Experience								Experience Acquired		
	Yr Begun				Starting Month	Ending Month	Brief Description	Attachment(s)	Verifying Supervisor or Other Mentor	PE?	Date
Outcome 9 - Design **See Guidelines for description.**	1				Aug-06	Nov-09	Recommended appropriate specifications from practice/industry standards, governmental agency requirements, manufacturer's standards, and other sources in the support of a 4-lane, state highway bridge design over the Kaskaskia River.	A1-A36	John Smith	Y	11/17/09
			3		May-08	Jan-09	Assessed the life-cycle costs and expected performance of design alternatives for a state highway connector and bridge project, quantitatively addressing capital and development costs as well as long term operation support and maintenance costs.	B1-B17	John Smith	Y	1/29/09

Statement by Supervisor or Other Mentor Verifying Relevant Experience				
Marilyn worked directly under my supervision for 29 months after joining the firm on a project team preparing a comprehensive specification package for a large turnkey highway project. She researched applicable standards and regulatory requirements, then drafted specifications to meet our company's and client's preferred format. She has also assessed life-cycle costs and expected performance on a design alternatives analysis. Her ability to take on design responsibilities has grown and I have rapidly increased her authority accordingly.	**Position:**	Project Engineer		
	Organization:	Riverplace Engineering Corp		
	Address:	27 Water Street DeMoines, IA 21229		
	Telephone:	713-444-2975		
	Email Address:	jsmith@riverplace_ec.net		
See Attachment NA **for continuation of Statement. If none, enter "NA".**	**Signature:**		**Date:**	

Figure A.1 – Completed Form 1 for Marilyn Johnson's First Design Activity

FORM 1
List of Relevant Experiences

Engineer Intern: **Marilyn Johnson**

Use this form to identify ONE OR MORE relevant experiences relating to ONE OUTCOME verifiable by ONE supervisor or other mentor.
Fill in only yellow and blue highlighted blocks. Blue highlighted experience description blocks will expand to accommodate text as needed.

Outcome	Relevant Experience								Experience Acquired		
	Yr Begun				Starting Month	Ending Month	Brief Description	Attachment(s)	Verifying Supervisor or Other Mentor	PE?	Date
Outcome 9 - Design See Guidelines for description.				4	Feb-09	Mar-10	Participated in explaining design decisions to county highway representatives, including alternatives considered and reasons for decisions made including management of risks, costs, and meeting client objectives.	C1-C7	Bill Jackson	Y	2/3/10

Statement by Supervisor or Other Mentor Verifying Relevant Experience		
Since joining our firm, Marilyn has demonstrated growing discernment and the capability to evaluate a design solution's ability to meet the various constraints imposed by regulatory requirements, our clients, and our partners. Our clients have already grown to rely on her ability to assess design alternatives and often follow her lead on choosing solutions. She has attained Outcome 9.		
See Attachment	NA	for continuation of Statement. If none, enter "NA".

Position:	Principal Engineer		
Organization:	Jackson and Associates, LLC.		
Address:	111 Main Street Plainfield, IA 21229		
Telephone:	713-563-3397		
Email Address:	wjackson@jallc.com		
Signature:		**Date:**	

Figure A.2 – Completed Form 1 for Marilyn Johnson's Second Design Activity

FORM 2
Validation of Experience and Outcome Attainment

Engineer Intern: **Marilyn Johnson**

Use this form to identify ALL relevant experiences for ONE OUTCOME and to validate attainment of that outcome.
Fill in only highlighted blocks. Experience blocks will expand to accommodate text as needed.

Name of Validating Supervisor or Other Mentor:	Bill Jackson	**Address:**	111 Main Street
Employer or Organization:	Jackson and Associates, LLC.		Plainfield, IA 21229
Position:	Principal Engineer		
		Telephone:	713-563-3397
		Email Address:	wjackson@jallc.com

Statement by Supervisor or Other Mentor Validating Outcome Attainment
Marilyn has demonstrated growing discernment and the capability to evaluate a design solution's ability to meet the various constraints imposed by regulatory requirements, our clients, and our partners. Our clients have already grown to rely on her ability to assess design alternatives and often follow her lead on choosing solutions. She has attained Outcome 9.
See Attachment NA **for continuation of Statement. If none, enter "NA".**

"Copy" and "Paste" directly onto the lines below from blue highlighted rows on each Form 1 for this outcome.

Outcome	**Relevant Experience**								**Experience Acquired**		
	Yr Begun				**Starting Month**	**Ending Month**	**Brief Description**	**Attachment**	**Verifying Supervisor or Other Mentor**	**PE?**	**Date**
Outcome 9 - Design **See Guidelines for description.**	1				Aug-09	Nov-09	Recommended appropriate specifications from practice/industry standards, governmental agency requirements, manufacturer's standards, and other sources in the support of a 4-lane, state highway bridge design over the Kaskaskia River.	A1-A36	John Smith	Y	11/17/09
			3		May-09	Jan-09	Assessed the life-cycle costs and expected performance of design alternatives for a state highway connector and bridge project, quantitatively addressing capital and development costs as well as long term operation support and maintenance costs.	B1-B17	John Smith	Y	1/29/09
				4	Feb-09	Mar-10	Participated in explaining design decisions to county highway representatives, including alternatives considered and reasons for decisions made including management of risks, costs, and meeting client objectives.	C1-C7	Bill Jackson	Y	2/3/10

Figure A.3 – Completed Form 2 for Marilyn Johnson's Attainment of the Design Outcome

This page intentionally left blank

Chapter 8

Modifying the Model Laws and Rules for Engineering Licensure

Jon D. Nelson, P.E., Dist.M.ASCE, M.NSPE, *Tetra Tech, Inc.*

Craig N. Musselman, P.E., Dist.M.ASCE, F.NSPE, F.ACEC, BCEE, *CMA Engineers*

Michael J. Conzett, P.E., BCEE, M.ASCE, *HDR, Inc.*

Monte L. Phillips, Ph.D., P.E., F.ASCE, F.NSPE, F.NAFE, *University of North Dakota*

Originally published as "The Raise the Bar Initiative: Charting the Future by Understanding the Path to the Present—Modifying the Model Laws and Rules for Engineering Licensure," in *Proceedings of the 2012 Conference of the American Society for Engineering Education*, June 2012.

The "Raise the Bar" Initiative: Charting the Future by Understanding the Path to the Present Modifying the Model Laws and Rules for Engineering Licensure

Abstract

Beginning in 1995 at the American Society of Civil Engineers (ASCE) Civil Engineering Education Conference (CEEC '95), key educational and professional leaders of the civil engineering community in the United States have been working to reform civil engineering education. In 1998, the call for action from CEEC '95 ultimately resulted in the passage of ASCE Policy Statement 465—Academic Prerequisites for Licensure and Professional Practice (PS 465). PS 465 states that in the future, education beyond the baccalaureate degree will be necessary for entry into the professional practice of civil engineering. In 2002, an ASCE Board-level committee, the Committee on Academic Prerequisites for Professional Practice (CAP^3), was formed to study and implement the actions that would be necessary to achieve this vision for civil engineering. The last 10 years have produced significant progress in ASCE's "Raise the Bar" initiative.

To maintain the initiative's momentum, the successful processes of the past and the associated "lessons learned" must be clearly communicated to future leaders and proponents of the "Raise the Bar" initiative. Much has been learned from the experiences of the past – and these hard-learned experiences should guide the future direction of the initiative. A quotation (from Adlai E. Stevenson) comes to mind: "We can chart our future clearly and wisely only when we know the path which has led to the present."

This is one of several scholarly papers that will be written and presented in recognition of the tenth anniversary of establishing CAP^3. The collective papers will provide engineering educators and practitioners with a description of the history, lessons learned, and next steps related to the "Raise the Bar" initiative. These papers will be written from six different, yet related, perspectives including the (1) overall initiative, (2) civil engineering bodies of knowledge, (3) changed university curricula, (4) experiential guidelines, (5) revised accreditation criteria, and (6) modified licensure laws and rules. This paper addresses the sixth perspective: the process of modifying the educational standards for engineering licensure in the state laws and rules.

Because ASCE considers "professional practice" to mean "licensed practice," implementation of the "Raise the Bar" initiative must include the modification of the requirements for engineering licensure. Individual states and other U.S. jurisdictions regulate the practice of engineering through their licensure laws and rules; therefore, implementation will ultimately have to include law and rule changes at the state level. However, the National Council of Examiners for Engineering and Surveying (NCEES) maintains model documents called the *Model Law* and the *Model Rules*. These documents represent a consensus of what the licensure boards across the United States believe the law and rules should look like, and they are generally used as a guide

when jurisdictions consider statute or rule revisions. Consequently, the first step in the process of modifying the licensure requirements in the states was for NCEES to modify its models. This paper addresses the process followed by the NCEES to make these modifications. It describes the history, the lessons learned as perceived by the authors, and the next steps for implementation of the new educational standards. It also includes the experiences, observations, reflections, and opinions of the authors: four individuals who participated in the process of changing the NCEES models.

Introduction

The practice of engineering is regulated through licensure in all 50 states, the District of Columbia, Guam, Puerto Rico, and the U.S. Virgin Islands. Each of these 54 jurisdictions has its own statutes and rules that establish licensure requirements to practice engineering (qualifications) and how that practice is conducted (procedures and conduct). The statutes and rules also establish that the requirements are to be administered and enforced by licensure boards, which are generally made up of both professional and public members. The boards regulate as an arm of government, but the engineering profession is represented in the regulatory process by virtue of their professional members.

In 1907, Wyoming enacted the first state statute to address engineering practice in the United States. By the end of 1919, 10 states had licensure laws, and by the end of the following year, 20 states had such laws. By 1920, significant state-to-state differences in the qualifications for licensure indicated the need for a central body to coordinate the individual state efforts, and the Council of Boards of Engineering Examiners was formed[1]. Today, that organization is called the National Council of Examiners for Engineering and Surveying (NCEES).

NCEES consists of 69 licensure boards. Of these, 40 regulate both engineering and surveying, 14 regulate only engineering, 14 regulate only surveying, and one regulates only structural engineering. Each board has an equal vote on all motions at the NCEES annual meeting, whether related to engineering or surveying. NCEES is subdivided regionally into four zones: Central, Northeast, Southern, and Western. Each zone elects one vice president who serves on the NCEES board of directors, along with the other members—president, president-elect, immediate past-president, and treasurer—who are elected at large. The zones also meet independently each spring to be briefed on issues that will be considered at the NCEES annual meeting and to develop zone-sponsored positions, motions, and resolutions.[2, 3]

Although NCEES has made significant progress over the past 90 years toward uniformity in the state laws and rules, the requirements for licensed practice still vary from jurisdiction to jurisdiction. A number of factors will always result in some variability: These include conditions peculiar to a particular region or state; the type of jurisdiction and nature of its formational documents; the jurisdiction's historical approaches to regulation; politics; and the manner in which legislation and regulations are promulgated in the United States—by open debate with both political and public participation. However, NCEES continues to strive toward a greater level of uniformity. The primary way it does this is by maintaining the NCEES *Model Law* and *Model Rules (ML&MR)*. These model documents reflect a consensus of what the licensing boards from across the United States believe the licensure laws and rules should look like, and all licensure jurisdictions are encouraged to consider them whenever their statutes and/or rules are opened for revision.

The three primary qualifications required to obtain a license to practice engineering are education, experience, and examination. Since its inception, NCEES has essentially eliminated the variability in licensure examinations by developing nationally normed examinations that are used by all jurisdictions. A few supplemental state-specific examinations still exist, but the number continues to dwindle. Experience requirements also vary somewhat, but the differences are usually coupled with different educational pathways allowed for licensure. Variations in the educational requirements also remain common, although they continue to diminish as well. For example, few jurisdictions still allow individuals to be licensed based only on experience and examination without any formal education. Twenty years ago, that pathway was still common. Although that particular pathway has nearly been eliminated, several alternate pathways allowing something less than a degree from a program accredited by the Engineering Accreditation Commission of ABET, Inc. (EAC/ABET) still exist in many jurisdictions.

Before 2006, the NCEES *ML&MR* allowed three educational pathways to licensure. The basic pathway required a bachelor's degree (B.S.) from a program accredited by EAC/ABET. Two other pathways relating to post-baccalaureate degrees (masters and doctorates) existed, but these also had some connections to accreditation by EAC/ABET. Consequently, the minimum educational standard for licensure as expressed in the NCEES *ML&MR* was essentially the EAC/ABET B.S.[4]

Starting in 2001, movements—with roots in both ASCE and NCEES—were initiated to raise the level of the educational qualification for licensure to something beyond an EAC/ABET B.S. ASCE's PS 465 clearly recommended change, but NCEES also had its own concerns. The two movements grew concurrently and led to changes to the NCEES model documents. ASCE does not claim credit for the changes—the changes were clearly for NCEES to make—but ASCE was appreciative of the opportunities to participate in the process and did work to promote the outcome.

Early History

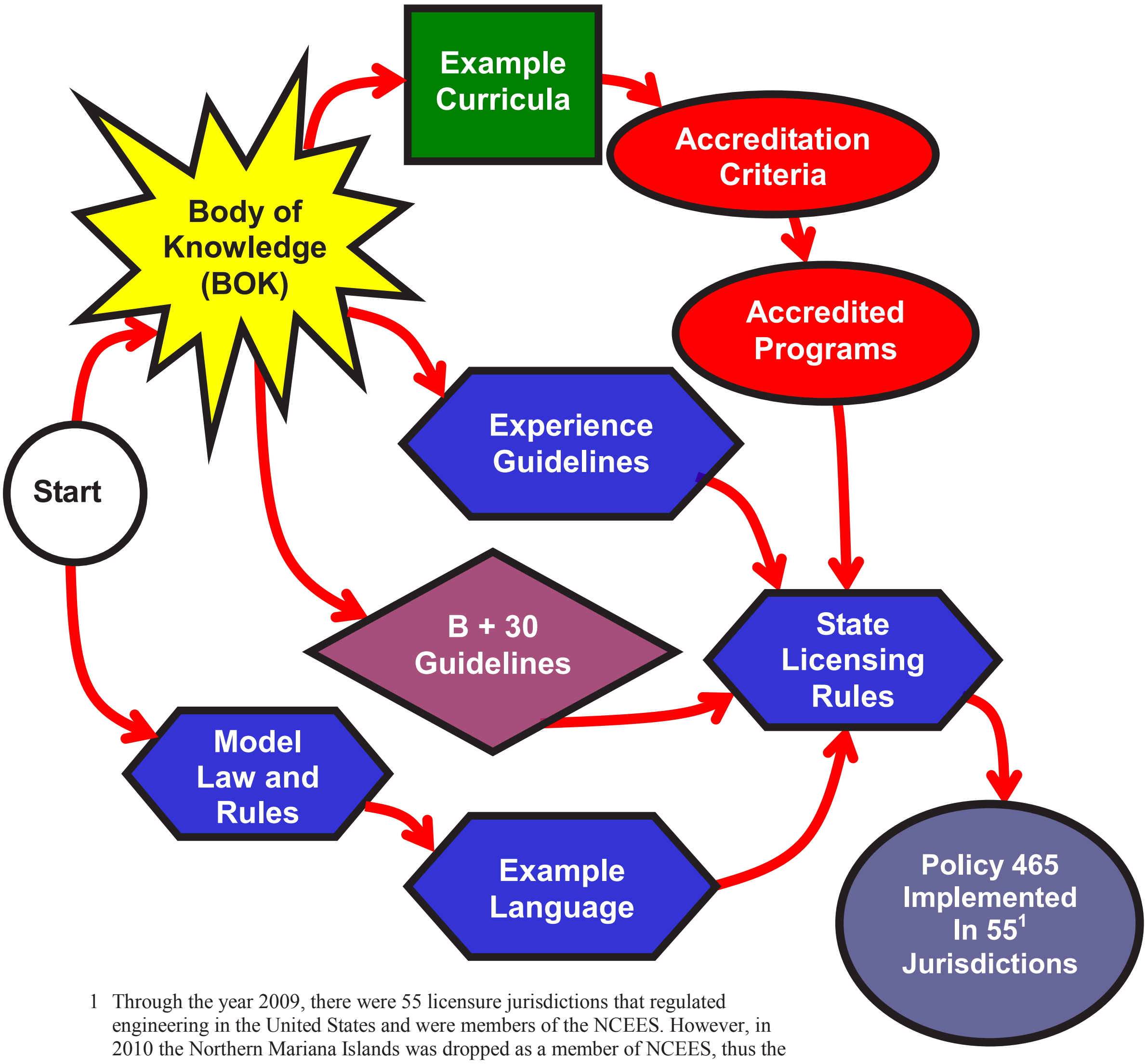
The American Society of Civil Engineers (ASCE) began a process to consider the state of civil engineering education in 1995 by convening the Civil Engineering Education Conference (CEEC '95). The report prepared by the CEEC '95 noted many changes confronting the civil engineering profession and suggested that the profession must respond proactively. The report also concluded that the current four-year baccalaureate degree was becoming inadequate for academic preparation for the professional practice of civil engineering. CEEC '95's call for action resulted in the adoption in 1998 of the first version of ASCE Policy Statement 465, which supported the "concept of the Master's Degree as the First Professional Degree for the practice of civil engineering at the professional level."[5] After further committee work, in 2001 ASCE revised the preamble of the policy to say that ASCE "supports the concept of a master's degree or equivalent as a prerequisite for licensure and the practice of civil engineering at the professional level."[6] This statement equated "practice at the professional level" with "licensed practice" and thus made licensure an important part of the initiative.

Immediately after adoption of the second version of PS 465, ASCE formed a task committee to implement the policy. Later, the group was elevated to a full board committee called the Committee on Academic Prerequisites for Professional Practice (CAP^3).[7] As shown in Figure 1, the CAP^3 plan for the implementation of PS 465 includes several activity paths, all of which culminate with the modification of the statutes and rules governing engineering practice in all licensure jurisdictions.[8] All of the paths have to be completed for ASCE to realize full implementation. The bottom path was handled by the Licensure Subcommittee of CAP^3. The first step in that path was to work with the NCEES in amending the *ML&MR* to reflect the additional education requirements consistent with the provisions of PS 465. This paper addresses ASCE's involvement in the process to complete and maintain this first step.

Since its inception, members of CAP^3 have made hundreds of presentations on the initiative. The presentations helped the committee learn what the profession thought about the education issue and at the same time allowed it to share ASCE's position. CAP^3 also developed a detailed body of knowledge (BOK)[9] required for professional practice in civil engineering and assisted with establishing a vision for civil engineering in 2025 through its involvement with the preparation of the report *Vision for Civil Engineering in 2025*.[10] These works led to a refinement of PS 465 in 2007 that now "supports the attainment of a Body of Knowledge (BOK) for entry into the practice of civil engineering at the professional level."[11]

Work of the ELQTF: 2001—2003

One of the earliest presentations relating to PS 465 by CAP^3 was in 2002 to an NCEES-sponsored group called the Engineering Licensure Qualifications Task Force (ELQTF). ELQTF was formed by NCEES to "assess the current licensure process (three E's) in regard to licensure qualifications …. and make recommendations for enhancement or change."[12] The task force was made up of two representatives from each of the four NCEES zones plus several other representatives from outside NCEES. In an attempt to have ELQTF represent the entire engineering profession, NCEES invited over 20 engineering societies to participate on the task force. Nine societies (AAEE, ABET, ACEC, ASCE, ASHRAE, ASME, EDC/ASEE, IEEE-USA, and NSPE) from the United States and one from Canada (CEQB) participated as "society members," and 11 others agreed to be "consulting members" and monitor the work of the task force. Each of the society members had full voting rights during the deliberations.[12]



1 Through the year 2009, there were 55 licensure jurisdictions that regulated engineering in the United States and were members of the NCEES. However, in 2010 the Northern Mariana Islands was dropped as a member of NCEES, thus the number of jurisdictions represented in NCEES dropped to 54.

Figure 1 – CAP^3 Implementation Plan[8]

ELQTF finished its work in 2003 and made its report to NCEES at the 2003 annual meeting. One of its recommendations addressed the educational qualification for licensure. While the recommendation did not go as far as proposed by ASCE's PS 465, it did call for strengthening the educational requirements for licensure. The task force concluded that "engineering education is falling behind other professions in preparing students for practice." Reasons cited included a continuing decline in the credit hour requirements for engineering degrees and the loss of depth in the engineering education due to the addition of "important but nontechnical professional training." ELQTF cited ASCE's position and recommended "that the Model Law provide for at least a bachelor's degree plus additional coursework in specialties related to practice." The task force did not prescribe the number of courses or the type of additional coursework required.[13]

Modifying the NCEES *Model Law* and *Model Rules*

NCEES accepted the ELQTF report at its August 2003 annual meeting and formed a new committee to consider the task force recommendations. This committee, called the Licensure Qualifications Oversight Group (LQOG), consisted of only NCEES members and brought the issues in-house for internal deliberation. LQOG was charged to "research the conclusions and recommendations contained in the ELQTF report and prepare appropriate recommendations for NCEES consideration…." After reviewing ELQTF's work, LQOG made a motion at the 2004 NCEES annual meeting to "consider initiating a process to determine specific recommendations regarding additional engineering education for the purpose of licensure and prepare an implementation plan."[14] The motion passed with 37 in favor and 24 against (some boards did not vote), and work to establish the details of the additional education requirements was initiated.[15] The margin of passage indicated that a majority of NCEES member boards agreed that the educational standard for licensure needed to be strengthened but also that a significant number did not. This was a harbinger of future debates on the issue.

Following the 2004 annual meeting, LQOG was continued and charged to "recommend revisions to the *Model Law* to require additional engineering education for the purpose of licensure." The group's work resulted in a motion at the 2005 NCEES annual meeting to charge the NCEES Committee on Uniform Procedures and Legislative Guidelines (UPLG) with incorporating the following language into the *ML&MR*:[16]

> "Graduation with a Bachelor of Science degree from an engineering program of four years or more accredited by EAC/ABET, or equivalent, plus 30 additional credits from an approved course provider(s) in upper-level undergraduate or graduate-level coursework in professional practice and/or technical topic areas."

The motion passed by a 35 to 26 margin, and the language was forwarded to UPLG for incorporation into the *ML&MR*.[17] UPLG is a standing committee of NCEES and serves as the custodian of the model documents. UPLG typically receives language developed by other NCEES committees/task forces and approved by vote at the annual meeting. It then fine-tunes the language and presents the motions to include the final language in the *ML&MR*. The committee maintains the intent of all language approved by NCEES but modifies the language as needed for proper incorporation into the documents.

After a year of deliberation, UPLG made a motion at the 2006 annual meeting to add to the *ML&MR* language that was effectively the same as that proposed the year before by LQOG.[18] The motion was a major topic of discussion at the meeting, both formally and informally, and the debates were intense. Both opponents and proponents were well prepared with their comments. The formal debate on the floor of the meeting lasted for nearly an hour—very long by NCEES standards—until the question was called. One concern voiced by the opponents during the debate was that the proposed language was too vague for implementation. Proponents agreed with this point and noted that additional work on the language was necessary; however, they also suggested that after five years of consideration, it was time to act and to let the profession know where NCEES stood on the issue of education. The vote was 39 in favor and 27 against.[19]

ASCE viewed this vote as accomplishing the first step of the licensure path of the ASCE CAP^3 plan for implementation of PS 465, but the effort was far from over.

Refining and Defending the New *Model Law* and *Model Rules*

In response to the concern voiced during the debate over the UPLG motion, the approved language was sent back to UPLG with the request to develop a definition for "approved credits" and "approved course providers." UPLG developed additional language and presented the proposed additions at the NCEES zone meetings in spring 2007. The debate at the zone meetings was extensive and reflected a wide variety of opinion on the definitions. After witnessing the zone debates, the NCEES board of directors suggested that UPLG withdraw the motion it had proposed for the 2007 annual meeting and refer the issue back to the committee for additional work. This suggestion was accepted by the UPLG, and no related motion was offered by UPLG at the 2007 NCEES annual meeting.[20] However, the 2007 annual meeting was not without actions relative to the education issue. Two other actions were proposed.

The first proposed action was an NCEES Western Zone resolution stating that the NCEES actions over the previous three years did nothing to stop the further reduction of credits required for a bachelor's degree. It resolved:

> "That NCEES strongly urges ABET to institute a set minimum number of credits that shall be required to graduate with a bachelor's degree in engineering;
>
> That a set percentage of the total required credits shall be courses defined by ABET as engineering topics, consisting of engineering sciences and engineering design appropriate to the student's field of study; and
>
> That the professional societies that oversee the ABET accreditation of each engineering program shall determine these parameters."

The resolution did not address just the decline in credit hour requirements. It also suggested that a process be initiated to correct the deficiencies in engineering education through the accreditation process. The resolution passed by 41 to 24 margin.[21] The vote seemed to confirm that a significant majority of the NCEES members felt the education qualification for licensure needed to be strengthened but that accreditation should be the means of the reform. The resolution was presented to ABET by the NCEES leadership; however, as of the date of this paper, ABET has not acted on the requests included in the resolution.

The second proposed action was a floor motion from the Nevada board. It requested that the 2006 vote on the UPLG motion to amend the *ML&MR* requirements for additional education for engineering licensure be rescinded.[20] This was the first attempt by opponents to eliminate the new requirement. The motion failed by a vote of 19 to 40.[21] The vote again indicated that a significant majority of the NCEES boards felt that the educational standard for licensure needed to be strengthened. However, these two votes seemed to indicate that several of the licensure boards were not completely comfortable with the approach reflected by the new language in the *ML&MR*.

After UPLG withdrew its motion in 2007, NCEES formed a new task force called the Bachelor's Plus 30 Task Force. The task force was charged with refining the language in the *ML&MR* so that the provisions could be better implemented by the licensure jurisdictions. As with ELQTF, the task force also included participation from outside engineering societies, including AIChE, ASCE, ASHRAE, ASME, NSPE, ACEC, and IEEE-USA. The societies participated in all meetings and all discussions but did not have voting rights.

The Bachelor's Plus 30 Task Force presented two motions at the 2008 NCEES annual meeting. One motion addressed additional language for the *ML&MR*. More specifically, it provided definitions of "acceptable upper-level undergraduate and/or graduate-level coursework" and "approved course providers" and recommended that the language be referred to the appropriate committee (UPLG) for incorporation into the *ML&MR*. The motion passed after some debate by a 34 to 26 margin.[22,23] The vote seemed to reflect the same disposition of the NCEES member boards as the engineering education-related votes of 2005 and 2006.

The second motion recommended that an appropriate committee be charged with "exploring the idea of a national clearinghouse that would carry out the activities needed to implement the bachelor's plus 30 requirements for engineering licensure." The task force realized that the types of additional courses and the course providers would have to be verified and approved by some entity and that a national approach would relieve the jurisdictions of the additional work load and provide uniformity.[22] The motion passed with no discussion on the floor by a vote of 55 to 7.[23]

At the 2008 NCEES annual meeting, the Western Zone proposed a resolution that listed several points supporting the position of the opposition and resolved the following:

> "That the development of the criteria for B+30 be **suspended** [emphasis added] until the membership of NCEES and the appropriate professional engineering organizations be provided with a written analysis of 1) the above listed points as appropriate; 2) the educational, professional, regulatory, and economic impact of B+30; and 3) any alternative solutions to the concept of additional education that have been or might be identified (including items such as additional experience before licensure in lieu of additional education, etc. The purpose of these reports would be to allow NCEES jurisdictions to make a more informed decision regarding B+30. It would be expected that this analysis could be completed by the time of the 2009 interim zone meetings with a **vote at the 2009 Annual Meeting to either continue B+30 development or discontinue the B+30 concept and remove all references to it in the NCEES *Model Law*** " [emphasis added].

The resolution appeared to represent another attempt to rescind the new educational requirements in the *ML&MR*. The Southern Zone offered a substitute resolution after discussion with the Western Zone. The substitute motion made some changes to the listed points and deleted the phrases that would suspend further work on the bachelor's plus 30 criteria and that would call for an up-or-down vote on the concept in 2009. The substitute resolution also proposed that the existing Bachelor's Plus 30 Task Force be charged with providing an analysis of the points and impacts and considering alternatives.[23] The substitute resolution passed with 57 boards in favor and 6 opposed.[23]

Addressing Implementation and Continuing the Defense: 2008—2009

The next year, the Bachelor's Plus 30 Task Force continued under the new name of the Engineering Education Task Force. The task force was charged to address the 2008 Southern Zone resolution (perform the analyses); explore the creation of a clearinghouse (proposed by the 2008 Bachelor's Plus 30 Task Force); develop a program and white paper to communicate the NCEES position on the educational requirements; and provide assistance to UPLG with the language proposed by the 2008 Bachelor's Plus Task Force. The Engineering Education Task Force prepared a lengthy report that addressed the analyses, offered possible alternative licensure pathways, and included a white paper. The task force also developed a flowchart to demonstrate how a national clearinghouse might function. At the 2009 NCEES annual meeting, the task force moved to charge "an appropriate committee or task force" with "further developing a national clearinghouse." The motion passed by a vote of 50 to 11.[24,26]

UPLG also offered a motion in 2009 to incorporate into the *ML&MR* the expanded definitions of "acceptable upper-level undergraduate and/or graduate-level coursework" and "approved course providers" prepared in 2008 by the Bachelor's Plus 30 Task Force.[25] The motion passed by a vote of 61 to 3 with no debate.[26] (See Appendix A, *Model Rules* Provisions, 230.10, parts B and C for the expanded definitions.)

Several other motions and resolutions were offered during the 2009 annual meeting. The first was from the Western Zone, which resolved that the Engineering Education Task Force should develop an alternate pathway. Instead of adding 30 credits or a master's degree after the B.S., this new pathway would require "additional continuing education in the form of 150 contact hours and a structured mentoring program that would assure the quality of the professional experience." The Central Zone offered a substitute resolution for the Engineering Education Task Force to add the proposed alternate pathway to the proposed alternatives instead of replacing them and to develop, evaluate, and report on all of the alternatives. The Central Zone substitute resolution was accepted in lieu of the Western Zone version, but it was subsequently defeated by a vote of 29 for and 32 against.[26]

The Southern Zone also proposed a resolution initiated by the Alabama board. It confirmed the need for further study of alternative pathways but resolved that the "study include reform to the bachelor's degree program such that a B.S. degree be modified to contain the appropriate educational requirements to practice at a professional level." The resolution was another attempt to find a way for accreditation (i.e., EAC/ABET) to address the educational concerns. The resolution passed 50 to 11 with little discussion.[26]

The Alaska board offered the last resolution at the 2009 NCEES annual meeting. It resolved:

> "That the NCEES president reconvene an ELQTF-type special task force composed of representatives of NCEES on both sides of this issue, representatives of professional societies who have voting rights on ABET and representation

> from their ABET liaisons, as well as ABET, and other engineering education stakeholders, with the intent to examine the future needs of engineering curricula and creation of a roadmap for assuring that future graduate engineers are appropriately prepared for engineering careers and registration as professional engineers."

Nevada offered an amendment to the resolution, calling for the removal of all references to additional education in the model documents pending further study. The proposed amendment and the original resolution failed by votes of 15 to 48 and 20 to 42, respectively.[26] The first vote indicated that a strong majority of NCEES did not want to move away from the initiative. The second vote may indicate that NCEES members were beginning to understand that accreditation cannot necessarily address their concerns. Overall, the 2009 votes reflected strong NCEES support for change to the educational requirements for licensure and the need to address the matter through the *ML&MR*. However, the votes still reflect some uncertainty over the alternatives reflected in the adopted language.

Considering Additional Alternatives: 2009—2011

Following the 2009 annual meeting, the Engineering Education Task Force continued and was charged to address potential alternative pathways to licensure. It proposed two additional alternatives for consideration at the 2010 NCEES annual meeting. One concerned bachelor degree programs that require 150 or more credit hours and meet certain requirements for content. This alternative actually reflects some existing bachelor programs, specifically within architectural engineering. The task force moved for UPLG to be charged with including this pathway in the *ML&MR*.[27] NCEES passed the task force motion 35 to 28.[28]

The Engineering Education Task Force also made a motion that addressed an alternative proposed by some of the engineering societies participating on the task force to better represent engineers practicing in industrial settings. The proposed pathway required the completion of some number (to be determined) of assessed learning days (ALDs) of continuing education plus six years of progressive experience, the final three of which (the three years just prior to taking the licensure exam) would be mentored by a licensed professional engineer. The intent of this alternative was to represent the diverse nature of education acquired by engineers who work in industry. Many engineers practicing in this kind of setting learn skills that are directly related to their work while on the job. Accordingly, the ALD term was proposed to reflect continuing education that is significantly more rigorous than typical post-licensure continuing education courses.[27] The task force motion to charge another committee with further study of this alternative passed 46 to 13.[28]

Following the 2010 annual meeting, a new task force was convened to study the alternate "industrial" pathway proposed for further study (ALDs plus mentored experience). The task force, called the Alternative Licensure Pathway Task Force, reviewed the proposed pathway in detail. It defined ALDs, recommended that 60 ALDs be completed in the six-year experience period, and defined the mentoring requirements. The task force made a motion at the 2011 NCEES annual meeting to refer the alternative to UPLG for incorporation into the *ML&MR*.[29] During the meeting, representatives of some of the societies that proposed the alternative as part of the Engineering Education Task Force spoke against the alternative. In addition, several boards voiced concern for the different standard for the experience qualification (the mentoring) and the definition of ALDs. The motion failed by a vote of 26 to 34.[30]

The votes of 2009, 2010, and 2011 seem to indicate an increasing comfort level within NCEES that the approach of adding requirements to the EAC/ABET B.S. prior to professional licensure may be the best way to move forward. However, it also seems clear that NCEES continues to prefer to address its educational concerns through the accreditation process to the extent possible.

The key actions (recommendations, motions and resolutions) associated with the additional education issue at NCEES are summarized in the table below.

Summary of Key Actions at NCEES Annual Meetings

Date	Recommendation/Motion/Resolution	Result	Vote For/Against
August 2001	ELQTF recommends additional education as a requirement for licensure	Report Accepted	No Vote
August 2003	LQOG motion to consider process to determine recommendations for additional education	Passed	37/24
August 2005	LQOG motion to have UPLG incorporate language into the *ML&MR* for additional education	Passed	35/26
September 2006	UPLG motion to incorporate specific language into the *ML&MR* for additional education	Passed	39/27
August 2007	WZ resolution to urge ABET, Inc. to set minimum number of credits for bachelor's degrees	Passed	41/24
August 2007	Nevada board resolution calling on the NCEES to rescind the vote on UPLG motion of September 2006	Failed	19/40
August 2008	B+30 TF motion to have UPLG incorporate additional definitions into the additional education language of the *ML&MR*	Passed	34/26
August 2008	B+30 TF motion to explore the idea of a national clearinghouse	Passed	55/7
August 2008	SZ substitute resolution calling for analysis of concerns for the additional education language and development of alternatives	Passed	57/6
August 2009	UPLG motion to incorporate additional definitions into the *ML&MR* for additional education	Passed	61/3
August 2009	EETF motion to further develop a national	Passed	50/11

	clearinghouse		
August 2009	CZ substitute resolution to have EETF consider an alternate pathway with 150 contact hours plus structured mentoring	Failed	29/32
August 2009	SZ resolution to study reforming the bachelor's degree for practice at the professional level	Passed	50/11
August 2009	Alaska board resolution to convene ELQTF-type special task force to examine future educational needs	Failed	20/42
August 2010	EETF motion for UPLG to add an educational pathway in the *ML&MR* for 150 credit hour programs	Passed	35/28
August 2010	EETF motion to charge a committee to further study an "industrial" pathway with additional education and mentored experience	Passed	46/13
August 2011	ALPTF motion for UPLG to add the industrial pathway to the *ML&MR*	Failed	26/34

Legend:
ELQTF – NCEES Engineering Licensure Qualifications Task Force
LQOG – NCEES Licensure Qualifications Task Force
UPLG – NCEES Committee on Uniform Procedures and Legislative Guidelines
B+30 TF – NCEES Bachelor's Plus 30 Task Force
EETF – NCEES Engineering Education Task Force
ALPTF – NCEES Alternative Licensure Pathway Task Force
WZ – NCEES Western Zone
SZ – NCEES Southern Zone
CZ – NCEES Central Zone

Current Status

After the votes of 2009, the education issue seems to have entered a state of rest at NCEES. Current NCEES leadership appears to be interested in having the industrial alternative considered further, but the disposition of this possibility is unknown. The 2010 and 2011 NCEES annual meetings represented two consecutive meetings without significant debate over current educational provisions in the *ML&MR*. While several boards remain in vocal opposition, active opposition has—at least for the time being—subsided. The current language in the *ML&MR* is summarized in Appendix A of this paper.

ASCE's Approaches to Supporting Licensure Reform

Until the 2006 NCEES vote to officially add the additional education requirements to the NCEES *ML&MR*, ASCE had little involvement in the NCEES annual meetings. ASCE was always represented and made presentations over the implementation of PS 465 at each meeting, but it had no organized efforts to provide support. However, the 2006 UPLG motion to incorporate specific language for additional education into the model documents was the key vote, and passage with the proper language was essential.

Up to that time, the NCEES votes on education reform simply moved the process along and did not require formal commitment to the change. The UPLG vote of 2006 was to formally change the model documents, so the focus on the issue by the NCEES membership intensified. In addition, licensing boards in opposition had become more vocal at NCEES zone meetings and other engineering societies had become more involved. In response, ASCE stepped up its support of the initiative. ASCE involvement from this point forward included the following:

- ASCE continued to make presentations at workshops on issues relating to engineering education at the NCEES annual meetings. These presentations allowed for ASCE to communicate its position and disseminate information related to the upcoming votes.

- Actions and discussions at the spring NCEES zone meetings were monitored. This information provided a preview of the debates that would occur at the annual meeting and allowed ASCE to properly prepare for the meetings.

- The votes by licensure boards on each education-related issue were evaluated. This improved the understanding of where the various licensure boards stood on the issues and provided an indication of how their position may have been changing over time.

- Representatives of ASCE attended the NCEES annual meetings and engaged in informal discussions with NCEES members. Formal proposals at the meetings were monitored and recommendations offered for modification and action.

- Comments were prepared for presentations by the ASCE presidents. NCEES annual meetings included an opportunity for the leaders of major engineering societies to address the NCEES members on the meeting floor. ASCE ensured that the ASCE president was briefed on the specific issues to be addressed at the meetings and was provided recommended language that could be used in the address to affirm ASCE's support for the education initiative.

Lessons Learned

The authors cite the following lessons learned during their involvement with NCEES:

- Communication. Effective communication is critical when supporting change. In this case, effective communication meant clear, concise, and consistent messages delivered through a variety of avenues: personal contact instead of just formal presentations or written comments; engagement with decision-makers when opportunities presented themselves; and creation of opportunities to engage decision-makers. Repeated contact and conversation with the decision-makers was key. While the written word was also used, documents are not always read or understood. The most effective approach was through multiple, direct, and personal contacts, sometimes with a leave-behind written document.

- Vigilance and Tenacity. The NCEES effort to amend the model documents did not reach its maximum intensity until after the *ML&MR* were changed, and there were many ways to undo what had been done. ASCE was vigilant and tenacious in its support of the new provisions as attempts were made to rescind the changes to the *ML&MR*. ASCE will have to remain so until licensure jurisdictions adopt the new requirements. Even then, the organization must be ready to actively support the provisions at the state level, because the state law and rules can always be changed. Continuing and active support of this initiative will likely be necessary well into the future.

- Accreditation. It became clear over time that most NCEES members preferred that the educational concerns of licensure be addressed through the accreditation process. The EAC/ABET-accredited B.S. had been the NCEES gold standard for decades. During the deliberations and debates, the desire for ABET to handle the issues was expressed on many occasions. Accreditation is extremely important and will remain so, but it is limited in what it can do. Only about 20 percent of EAC/ABET graduates become licensed professional engineers. The educational requirements for licensed practice and its interest in protecting the public health, safety, and welfare may not apply to the other 80 percent of graduates who pursue careers in areas exempt from licensure. The limitations and complexities of accreditation are difficult to understand and extremely difficult to communicate, and it was difficult for some NCEES members to accept that effective reform of the educational requirements for licensure had to be accomplished by adding requirements to the existing gold standard rather than trying to expand the standard itself. The lack of response to the 2007 resolution calling for ABET to implement new requirements helped NCEES members to understand the limitations. However, as new NCEES members come onto boards, it is likely that the accreditation approach will continually be raised.

- Engineering Disciplines. The level of interest in licensure varies significantly from discipline to discipline within the engineering profession. This is reflected by the varying percentages of engineering graduates from each discipline that eventually pursue licensure. Civil engineering represents the largest group of licensed engineers because it has higher numbers handling public projects; these individuals must be licensed to be in responsible charge of the engineering work. Other disciplines have lower numbers because higher percentages of their engineers work in areas that are traditionally exempt from licensure. This fact produced some tension between ASCE, a staunch proponent of the educational reform, and other societies that stood in opposition. ASCE views itself as a major supporter of licensure due to its numbers and its positions (such as PS 465 that equates practice at the professional level with licensed practice). However, opposition societies also view themselves as strong supporters of licensure even though they represent fewer numbers of licensed engineers. ASCE found that it must be sensitive to this situation and respect the commitment of all societies with an interest in licensure.

- Regulators vs. Professionals. NCEES is a unique organization in the engineering profession. It is made up of engineers (and surveyors and public members) who are appointed to the licensure boards by politicians and who serve as regulators for the state. In general, licensure board members view themselves as regulators who happen to be

> professionals, not professionals who happen to be regulators, and they diligently maintain a distinction between their regulatory role and their professional role. They guard against looking like they are more interested in advancing the profession rather than in carrying out their charge of protecting the public health, safety, and welfare. While supporting the educational changes at NCEES, ASCE found that it had to be careful not to overemphasize the effect that the change would have on the profession. Instead, the proper approach was to focus on the purpose of the jurisdictional boards: "to safeguard the life, health, safety, and property and to promote the public welfare."[31]

Going Forward

Although ASCE sees the *ML&MR* as now being appropriately modified and the debate on the issue has diminished significantly, ASCE remains vigilant and does not consider the matter resolved. NCEES membership is constantly changing, and new members need to understand the history and complexities of the engineering education issue. Also, some NCEES boards are still opposed to the concept of additional education for engineering licensure, and they can make motions or resolutions at any annual meeting to remove the additional education requirements in the model documents. The language in the *ML&MR* cannot be taken for granted until the licensure jurisdictions implement the new requirements. Even when that happens, the provisions must be fully supported at NCEES and in the state legislatures.

Bibliography:

1. National Council of Examiners for Engineering and Surveying. 1996. *The History of the National Council of Examiners for Engineering and Surveying.*
2. NCEES. 2011. *NCEES Bylaws.*
3. NCEES. 2011. *NCEES Zone Meeting and Continuity Guidelines.*
4. NCEES. 2005. *NCEES Model Law and Model Rules*
5. ASCE. 1998. *Policy Statement 465, Academic Prerequisites for Professional Practice.* Adopted by the Board of Directors, October 1998.
6. ASCE. 2001. *Policy Statement 465, Academic Prerequisites for Professional Practice.* Adopted by the Board of Directors, November 2001.
7. ASCE. 2008. *Final Report to the ASCE BOD from Paraprofessional Exploratory Task Committee (PETC).* September 18, 2008.
8. Nelson. 2007. *CAP^3 presentation at the Oklahoma ASCE-OSPE joint meeting.* June 15, 2007.
9. ASCE. 2008. *Civil Engineering, Body of Knowledge for the 21st Century. Second Edition*
10. ASCE. 2007. *The Vision for Civil Engineering in 2025*
11. ASCE. 2007. *Policy Statement 465, Academic Prerequisites for Professional Practice.* Adopted by the Board of Directors, April 2007.
12. NCEES. 2001. *NCEES Action Items and Conference Reports—Report of the Engineering Licensure Qualifications Task Force, 80th Annual Meeting*. August 2001.
13. NCEES. 2003. *NCEES Action Items and Conference Reports—Report of the Engineering Licensure Qualifications Task Force.* August 2003.
14. NCEES. 2004. *NCEES Action Items and Conference Reports—Report of the Licensure Qualifications Oversight Group, 83rd Annual Meeting.* August 2004.
15. NCEES. 2004. *Minutes and Reference Material of the NCEES 83rd Annual Meeting and vote tallies.*
16. NCEES. 2005. *NCEES Action Items and Conference Reports—Report of the Licensure Qualifications Oversight Group, 84th Annual Meeting*. August 2005.
17. NCEES. 2005. *Minutes and Reference Material of the NCEES 84th Annual Meeting and vote tallies.*

18. NCEES. 2006. *NCEES Action Items and Conference Reports—Report of the Uniform Procedures and Legislative Guidelines Committee, 85th Annual Meeting*. September 2006.
19. NCEES. 2006. *Minutes and Reference Material of the NCEES 85th Annual Meeting and vote tallies.*
20. NCEES. 2007. *NCEES Action Items and Conference Reports—Report of the Uniform Procedures and Legislative Guidelines Committee, 86th Annual Meeting*. August 2007.
21. NCEES. 2007. *Minutes and Reference Material of the NCEES 86th Annual Meeting and vote tallies.*
22. NCEES. 2008. *NCEES Action Items and Conference Reports—Report of the Bachelor's Plus 30 Task Force, 87th Annual Meeting*. August 2008.
23. NCEES. 2008. *Minutes and Reference Material of the NCEES 87th Annual Meeting and vote tallies.*
24. NCEES. 2009. *NCEES Action Items and Conference Reports—Report of the Engineering Education Task Force, 88th Annual Meeting.* August 2009.
25. NCEES. 2009. *NCEES Action Items and Conference Reports—Report of the Uniform Procedures and Legislative Guidelines Committee*. *88th Annual Meeting*, August 2009.
26. NCEES. 2009. *Minutes and Reference Material of the NCEES 88th Annual Meeting and vote tallies.*
27. NCEES. 2010. *NCEES Action Items and Conference Reports—Report of the Engineering Education Task Force, 89th Annual Meeting.* August 2010.
28. NCEES. 2010. *Minutes and Reference Material of the NCEES 89th Annual Meeting and vote tallies.*
29. NCEES. 2011. *NCEES Action Items and Conference Reports—Report of the Engineering Education Task Force, 90th Annual Meeting*. August 2011.
30. NCEES. 2011. *Minutes and Reference Material of the NCEES 90th Annual Meeting and vote tallies.*
31. NCEES. 2012. *NCEES Model Law.* August 2011.

APPENDIX A
PROVISIONS RELATING TO THE EDUCATIONAL REQUIREMENTS FOR LICENSURE
NCEES *MODEL LAW* AND *MODEL RULES*—2011 (Current)

Model Law Provisions

130 LICENSURE
130.10 General Requirements for Licensure
Education, experience, and examinations (as described in *Model Rules)* are required for licensure as a professional engineer or professional surveyor.

A. As an Engineer Intern – The following shall be considered as minimum evidence that the applicant is qualified for certification as an engineer intern. A college senior or graduate of an engineering program of 4 years or more accredited by the Engineering Accreditation Commission of ABET (EAC/ABET), or the equivalent, or an engineering master's program accredited by EAC/ABET shall be admitted to an examination in the fundamentals of engineering. Upon passing such examination and providing proof of graduation, the applicant shall be certified or enrolled as an engineer intern, if otherwise qualified.
B. As a Surveyor Intern – *[Not reprinted in this appendix for brevity.]*
C. Professional Engineer or Professional Surveyor – To be eligible for admission to the examination for professional engineers or professional surveyors, an applicant must be of good character and reputation and shall submit five references acceptable to the board with his or her application for licensure, three of which references shall be professional engineers or professional surveyors having personal knowledge of the applicant's engineering or surveying experience.
    1. As a Professional Engineer – The following shall be considered as minimum evidence satisfactory to the board that the applicant is qualified for licensure as a professional engineer.
        a. Licensure by Comity – *[Not reprinted in this appendix for brevity.]*
        b. Licensure by Examination (Effective until January 1, 2020) – The following individuals shall be admitted to an examination in the principles and practice of engineering and, upon passing such examination and providing proof of graduation, shall be licensed as a professional engineer, if otherwise qualified:
            (1) An engineer intern with a bachelor's degree in engineering and with a specific record of 4 years or more of progressive engineering experience of a grade and a character which indicate to the board that the applicant may be competent to practice engineering
            (2) An engineer intern who satisfies one of the following education and experience requirements:
                (a) Following a bachelor's degree in engineering from an institution that offers EAC/ABET-accredited programs, earns a master's degree in engineering and establishes a specific record of 3 years or more of progressive engineering experience of a grade and a character which indicate to the board that the applicant may be competent to practice engineering
                (b) Following a master's degree in engineering from an EAC/M-ABET-accredited program, establishes a specific record of 3 years or more of

progressive engineering experience of a grade and a character which indicate to the board that the applicant may be competent to practice engineering

(3) An engineer intern with an earned doctoral degree in engineering acceptable to the board and with a specific record of 2 years or more of progressive engineering experience of a grade and a character which indicate to the board that the applicant may be competent to practice engineering

(4) An individual with an earned doctoral degree in engineering acceptable to the board and with a specific record of 4 years or more of progressive engineering experience of a grade and a character which indicate to the board that the applicant may be competent to practice engineering

c. Licensure by Examination (Effective January 1, 2020)[5] – The following individuals shall be admitted to an examination in the principles and practice of engineering and, upon passing such examination and providing proof of graduation, shall be licensed as a professional engineer, if otherwise qualified:

(1) An engineer intern who satisfies one of the following education and experience requirements:

(a) Following the bachelor's degree, an acceptable amount of coursework resulting in a master's degree in engineering from an institution that offers EAC/ABET accredited programs, or the equivalent, and with a specific record of 3 years or more of progressive engineering experience of a grade and a character which indicate to the board that the applicant may be competent to practice engineering

(b) Following a master's degree in engineering from an EAC/M-ABET-accredited program, a specific record of 3 years or more of progressive engineering experience of a grade and a character which indicate to the board that the applicant may be competent to practice engineering

(c) Following the bachelor's degree, an acceptable amount of coursework as defined in NCEES *Model Rules* Section 230.10 D from approved course providers and a specific record of 4 years or more of progressive engineering experience of a grade and a character which indicate to the board that the applicant may be competent to practice engineering

(d) Following a bachelor's degree from an EAC/ABET-accredited program that has a minimum of 150 semester credit hours, of which at least 115 are in math, science, and engineering combined and at least 75 of the 115 are in engineering, a specific record of 4 years or more of progressive engineering experience of a grade and a character which indicate to the board that the applicant may be competent to practice engineering

(2) An engineer intern with an earned doctoral degree in engineering acceptable to the board and with a specific record of 2 years or more of progressive engineering experience of a grade and a character which indicate to the board that the applicant may be competent to practice engineering

(3) An individual with an earned doctoral degree in engineering acceptable to the board and with a specific record of 4 years or more of progressive engineering experience of a grade and a character which indicate to the board that the applicant may be competent to practice engineering experience of a grade and a

character which indicate to the board 71 that the applicant may be competent to practice engineering

(4) An individual with an earned doctoral degree in engineering acceptable to the board and with a specific record of 4 years or more of progressive engineering experience of a grade and a character which indicate to the board that the applicant may be competent to practice engineering

c. Licensure by Examination (Effective January 1, 2020)[5] – The following individuals shall be admitted to an examination in the principles and practice of engineering and, upon passing such examination and providing proof of graduation, shall be licensed as a professional engineer, if otherwise qualified:

(1) An engineer intern who satisfies one of the following education and experience requirements:

(a) Following the bachelor's degree, an acceptable amount of coursework resulting in a master's degree in engineering from an institution that offers EAC/ABET accredited programs, or the equivalent, and with a specific record of 3 years or more of progressive engineering experience of a grade and a character which indicate to the board that the applicant may be competent to practice engineering

(b) Following a master's degree in engineering from an EAC/M-ABET-accredited program, a specific record of 3 years or more of progressive engineering experience of a grade and a character which indicate to the board that the applicant may be competent to practice engineering

(c) Following the bachelor's degree, an acceptable amount of coursework as defined in NCEES *Model Rules* Section 230.10 D from approved course providers and a specific record of 4 years or more of progressive engineering experience of a grade and a character which indicate to the board that the applicant may be competent to practice engineering

(d) Following a bachelor's degree from an EAC/ABET-accredited program that has a minimum of 150 semester credit hours, of which at least 115 are in math, science, and engineering combined and at least 75 of the 115 are in engineering, a specific record of 4 years or more of progressive engineering experience of a grade and a character which indicate to the board that the applicant may be competent to practice engineering

(2) An engineer intern with an earned doctoral degree in engineering acceptable to the board and with a specific record of 2 years or more of progressive engineering experience of a grade and a character which indicate to the board that the applicant may be competent to practice engineering

(3) An individual with an earned doctoral degree in engineering acceptable to the board and with a specific record of 4 years or more of progressive engineering experience of a grade and a character which indicate to the board that the applicant may be competent to practice engineering

5 The implementation of these provisions in all jurisdictions is anticipated to take a number of years, so the actual effective date will vary by jurisdiction. A minimum 8-year transition period subsequent to adoption by a jurisdiction is recommended to allow jurisdictions and prospective licensees to prepare for the new requirements. The 2020 date was selected as the earliest reasonable date for adoption by a jurisdiction based on a 4-year implementation period plus an 8-year transition period for first-time licensure candidates.

<u>*Model Rules*</u> <u>Provisions</u>

230 CANDIDATES FOR LICENSURE

230.10 Education Requirements Approved by the Board

A. Undergraduate Engineering Program
The term "an engineering program of 4 years or more" used in Section 130.10 A of the NCEES *Model Law* is interpreted by this board to mean:
1. A bachelor's degree in an engineering program accredited by EAC/ABET at the time of the awarding of the degree (The board may accept the degree if accreditation is received within a prescribed period of time.)
2. A bachelor's degree in an engineering program not accredited by EAC/ABET, such as those programs recently developed or programs offered by foreign schools, but deemed by the board to be substantially equivalent to those programs which have been accredited by EAC/ABET

B. Post-Graduate Engineering Course Providers
The term "approved course provider" used in Section 130.10 C.1.c of the *Model Law* is interpreted to mean the following:
1. An institution that has an EAC/ABET-accredited program;
2. An institution or organization accredited by an NCEES-approved accrediting body[3]; or
3. An institution or organization that offers specifically approved courses that are individually approved by an NCEES-approved accrediting body.[4]

C. Post-Graduate Acceptable Coursework
The term "acceptable upper-level undergraduate and/or graduate-level coursework" used in Section 130.10 C.1.c of the *Model Law* is interpreted to mean the following:
1. In technical topic areas, acceptable coursework shall be upper-level undergraduate and/or graduate-level courses in engineering.
2. Other topic areas of acceptable coursework shall be upper-level undergraduate and/or graduate-level courses relevant to the practice of engineering and may include engineering-related science, mathematics, and/or professional practice topics such as business, communications, contract law, management, ethics, public policy, and quality control.

D. Post-Graduate Minimum Required Education
The term "acceptable amount of coursework" used in Section 130.10 C.1.c of the *Model Law* is interpreted to mean the following:
1. A minimum of an additional 30 credits of coursework, none of which were used to fulfill the bachelor's degree requirement
2. All 30 additional credits shall be equivalent in intellectual rigor and learning assessments to upper-level undergraduate and/or graduate courses offered at institutions that have a program accredited by EAC/ABET.
3. Of the minimum required 30 additional credits, a minimum of 15 credits must comply with Section 230.10 C.1.
4. The term "credit" is defined as a semester hour, or its equivalent, from an approved course provider as defined in Section 230.10 B.

3 This institution/organization would be approved to develop and offer courses that meet *Model Rules*, Section 230.10 C. NCEES-approved accrediting bodies may include regional accreditation bodies and other appropriate discipline accreditations.

4 This institution/organization would be approved to offer one or more specifically approved courses that meet *Model Rules*, Section 230.10C.

Chapter 9

To Raise the Bar or Not: Addressing the Opposition

Stephen J. Ressler, P.E., Ph.D., Dist.M.ASCE, *U.S. Military Academy*

Originally published as “To Raise the Bar or Not: Addressing the Opposition,” in *Proceedings of the 2012 Conference of the American Society for Engineering Education,* June 2012.

To Raise the Bar or Not:
Addressing the Opposition

Background

Consistent with its *Vision for Civil Engineering in 2025*, the American Society of Civil Engineers (ASCE) has been engaged in an ambitious effort to better prepare civil engineering professionals to meet the technological, environmental, economic, social, and political challenges of the future.[1] This "Raise the Bar" initiative attained an important milestone in October 1998, when the ASCE Board of Direction formally adopted Policy Statement 465. The most recent version of this policy is as follows:

> The ASCE supports the attainment of a body of knowledge for entry into the practice of civil engineering at the professional level. This would be accomplished through the adoption of appropriate engineering education and experience requirements as a prerequisite for licensure.[2]

In conjunction with the implementation of Policy 465, ASCE initiated a comprehensive effort to formally define the profession's body of knowledge (BOK).[3] As the BOK has been developed and refined, a concurrent analysis has demonstrated that the prescribed BOK outcomes cannot be adequately achieved through the traditional four-year baccalaureate degree.[4] Consequently, Policy 465 specifies that the prerequisites for licensure should be (1) a baccalaureate degree in civil engineering, (2) a master's degree or approximately 30 graduate or upper-level undergraduate credits, and (3) appropriate progressive, structured engineering experience.

ASCE is currently attempting to influence state laws to reflect the increased educational requirement for licensure. In 2006, with ASCE's strong support, the National Council of Examiners for Engineering and Surveying (NCEES) modified its Model Law and Model Rules pertaining to engineering licensure.[5] The revised Model Law and Rules state that admission to the engineering licensing exam will require an accredited bachelor's degree in engineering, a master's degree or an additional 30 credits of acceptable upper-level undergraduate or graduate-level coursework, and four years of progressive engineering experience. In 2008, the effective date for the new Model Law was set at January 2020.

While the implementation of Policy 465 has made substantial progress since 1998, the process has often been contentious. Today, various aspects of the initiative are opposed by the Engineering Deans Council, the American Council of Engineering Companies, and professional societies affiliated with several other engineering disciplines. In April 2008, the American Society of Mechanical Engineers (ASME) Board of Governors approved a position paper opposing additional education as a prerequisite for licensure. This position paper, "Mandatory Educational Requirements for Engineering Licensure," was subsequently endorsed by eight other professional societies and the Executive Board of the Engineering Deans Council, and then published on a specially developed website.[6] The position paper is included as Appendix A of this paper.

Purpose

The purpose of this paper is to assess the key points of opposition presented in the ASME position paper, "Mandatory Educational Requirements for Engineering Licensure," from two complementary perspectives:

- Validity of each specific point of opposition, based on objective evidence, logic, and recent multi-disciplinary visions of the engineering profession's future.
- Consistency with the theoretical framework of professionalism, as described in the Sociology of Professions.

Addressing the Key Points of Opposition

The following paragraphs address the ten key points of opposition to the NCEES Model Law changes, as presented in the ASME position paper "Mandatory Educational Requirements for Engineering Licensure." Each point, enclosed within a border, is a direct quotation from the position paper. The numbers assigned to each point are my own; they are used strictly for ease of reference in this paper and do not reflect any particular priority.

> 1. "The low number of engineering students in four-year colleges has been going in the wrong direction nationally, as cited in the statistics below."

In support of this point, the position paper provides the following statistics:

- In 1981, 6.7 percent of degrees awarded were in engineering. In 1984, the figure rose to a high of 7.7 percent. Today it has dropped to 5 percent.
- During the past two decades, part of an era that has been described as science and engineering's greatest period of accomplishment, the numbers of engineers, mathematicians, physical scientists, and geoscientists graduating with bachelor's degrees in the United States have declined by 18%. The proportion of university students achieving bachelor's degrees in these fields has declined by almost 40% during that time.
- The number of engineering doctorates awarded by U.S. universities to U.S. citizens dropped by 23% in the past decade.*

The first of these statistics fails to support the point that engineering enrollments are "going in the wrong direction," because it describes only the *proportion* of degrees awarded. A decline in the proportion of degrees awarded does not necessarily indicate a decline in the *number* of degrees awarded. The second item obfuscates the point by aggregating engineering with mathematics, physical sciences, and geosciences. The third is simply irrelevant, as the number of doctorates awarded has little relationship to the number of engineering students in four-year colleges and has no impact on engineering licensure.

Figure 1, produced by the Engineering Workforce Commission of the American Association of Engineering Societies, illustrates undergraduate engineering enrollments over the period from 1970 to the present.[8] These data demonstrate unequivocally that undergraduate engineering

---

* These statistics were taken from a report by Norman R. Augustine, one of the profession's most prominent supporters of the master's degree as a prerequisite for the practice of engineering at the professional level.[7]

enrollments (1) are currently at an all-time high, (2) have been rising sharply since 1996, and (3) have been trending upward for the past decade. The position paper's claims that engineering enrollments are low and "going in the wrong direction nationally" are demonstrably false.

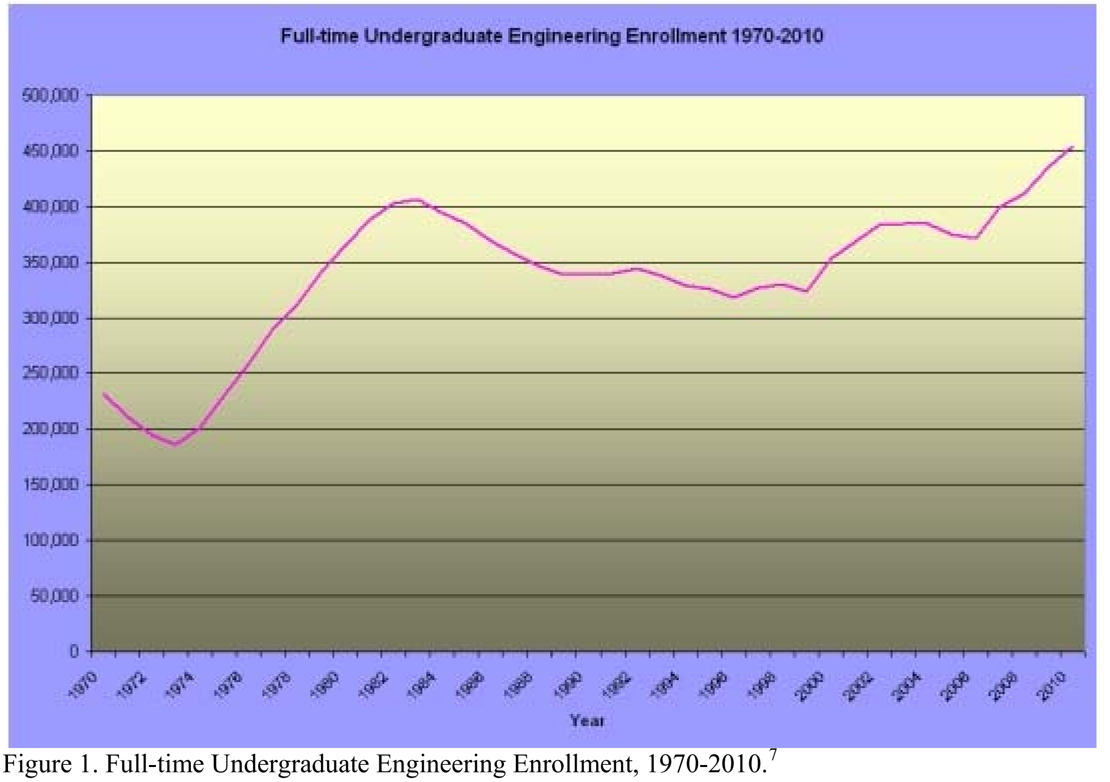


Figure 1. Full-time Undergraduate Engineering Enrollment, 1970-2010.[7]

Nonetheless, it is very likely that increased educational requirements for licensure *in a single engineering discipline* would significantly impact enrollments in that discipline. For this reason, ASCE's Raise the Bar initiative has been directed at the engineering profession as a whole, rather than on civil engineering alone.

2. "The engineering degree is one of the most challenging programs of study that one may undertake at the university and requiring an additional 30+* will make it even more difficult to attract the highly capable students we need to ensure our technological growth."

Here the ASME paper suggests that *we must preserve low standards for entry into the profession* to ensure that we have an adequate supply of engineers to ensure our technological growth. Yet there is compelling evidence that our future global competitiveness demands not *more engineers*, but *better educated engineers*.

Consider the report produced by a National Science Foundation (NSF)-sponsored project called "The 5XME Workshop: Transforming Mechanical Engineering Education and Research in the USA."[9] The 5XME project report describes the ongoing global commoditization of engineering

* The ASME position paper uses the terms "BS+30" and "30+" in reference to the NCEES Model Law requirement for 30 credits of acceptable upper-level undergraduate or graduate-level coursework.

education, resulting in the ready availability of low-cost engineering talent in various foreign countries. Observing that these off-shore engineers are typically able to provide routine engineering services at 20% of the cost of U.S. engineers, the report concludes that "The challenge for engineering schools in the USA is how to educate a mechanical engineer that provides five times the value added when compared to the global competition, i.e., the 5XME." According to the 5XME authors, U.S. mechanical engineers will only be able to provide five times more value than their foreign counterparts if they are able to develop greater breadth of intellectual capacity, an ability to innovate, and leadership in addressing major societal challenges. The authors of the 5XME Report are all mechanical engineers; however, they suggest that their findings are "broadly applicable to all fields of engineering."

Off-shoring may also be an underlying reason for the surprising results of a recent study by the RAND Corporation.[10] This study concludes that "there is no evidence of a current shortage of science and engineering workers" in the U.S. The 2008 report (which predates the current economic downturn) notes that a bona fide shortage of scientists and engineers would result in significant wage increases and declines in unemployment, neither of which is happening.

A more recent report by Georgetown University's Center on Education and the Workforce finds that the unemployment rate for recent graduates of undergraduate engineering programs is 7.5% percent—significantly lower than recent graduates with humanities and arts degrees (9.4% and 11.1%, respectively), but *higher* than recent graduates with agriculture, journalism, education, health, psychology, social work, and business degrees.[11]

These data clearly do not suggest a shortage of U.S. engineers with baccalaureate degrees. Demand for more highly educated engineers is significantly stronger, however. According to the Georgetown report, the current unemployment rate for U.S. engineers with graduate degrees is only 3.4%.

Taken together, these three sources suggest that ensuring a large supply of engineers by maintaining low educational standards makes no sense. In the context of intense global competition and the availability of low-cost engineering services overseas, turning out larger numbers of minimally qualified engineers will do little to enhance U.S. economic competitiveness and will do a grave disservice to the engineers themselves. Equipped only to do routine work, these U.S. engineers will be unable to compete with their lower-cost overseas counterparts, who can deliver the same services at a fraction of the cost. U.S. global competitiveness demands not more engineers but better-prepared engineers—those with the intellectual breadth, innovativeness, and leadership skills called for in the 5XME Report.

3. "Increasing the professional licensing requirements has the potential to reduce the supply of licensed engineers who are able to practice and therefore reduce our Nation's technological competitiveness."

In choosing the words "potential to reduce," the ASME position paper appropriately acknowledges that it is impossible to predict the future with certainty. Nonetheless, we can get some indication of how increased educational requirements for licensure are likely to affect the engineering profession by examining how it affected the certified public accountants (CPA) over the past two decades.

In 1989, the American Institute of Certified Public Accountants (AICPA) recommended that states require candidates to complete 150 credit hours of study before sitting for the CPA exam. At that time, a 120-hour requirement was the norm. The states responded slowly, but by 2009, 48 of 54 jurisdictions had adopted the 150-hour requirement. Subsequently, some states adopted a hybrid standard, allowing candidates to take the CPA exam after 120 hours of study but only attaining licensure after 150 hours.

The ASME "Licensing that Works" website briefly discusses the CPAs' adoption of additional educational requirements, citing a 2006 analysis by Carpenter and Stephenson.[12] This study examined states that had implemented the 150-hour rule, and discovered that the number of candidates sitting for the CPA exam in these states had been reduced by 60 percent.[13]

Although the Carpenter and Stephenson study was the only evidence cited by ASME, it tells only part of a much larger story. Several subsequent analyses provide a more comprehensive perspective of the very complex effects of the changing standards for CPA licensure. Carpenter and Hock analyzed longitudinal data from three states—Florida, which instituted a 150-hour requirement in 1983 (in advance of the AICPA vote); Texas, which adopted the requirement in 1998; and New York, which had not yet adopted the requirement at the time of the study.[14] Their results are summarized in Figures 2, 3, and 4 below.

- Figure 2 shows the number of CPA exam-takers (in blue) and their corresponding average pass rates (in red) in the state of Texas during the period 1991 to 2003. Here the effect of implementing the 150-hour rule in 1998 is quite pronounced. The law effecting the change included a "grandfather" provision allowing candidates who failed the exam prior to 1998 to re-take it in subsequent years, even if they did not meet the 150-hour standard. Thus, there was a surge in exam-takers in 1997, as candidates took advantage of this provision. Between 1996 and 2000, the drop in exam-takers was approximately 60%, just as Carpenter and Stephenson noted in their earlier study. Note, however, that a steady annual decline in exam-takers was already evident in the three years prior to the 1997 surge. Note also that the CPA exam pass rate increased significantly (over 70%) in the years following implementation of the new standard. Thus the decline in exam-takers after 1998 did not cause a commensurate decline in the number of registered CPAs.
- Figure 3 shows the corresponding graph for the state of Florida. In this case, the change to the 150-hour rule had occurred in 1983, nearly a decade prior to the earliest data acquired in the study. Here we see a steady decline in exam-takers from 1991 to 1998, followed by a distinct, if inconsistent upward trend. Throughout the period, pass rates vary between 21% and 33%—entirely consistent with the high pass rates achieved in Texas after the 150-hour rule was implemented in 1998.
- Figure 4 shows the number of exam-takers and pass rates in New York. Although the 150-hour rule was not implemented in New York during the period of the study, we still see a steady decline in both exam-takers and pass rates. These pass rates are significantly lower than those in Florida (where the 150-hour rule was in effect throughout the period) and in Texas after the 150-hour rule was implemented in 1998.

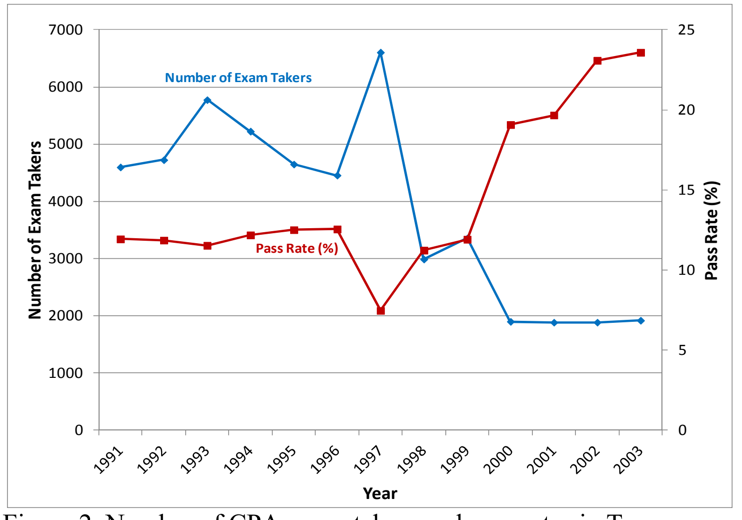


Figure 2. Number of CPA exam-takers and pass rates in Texas.

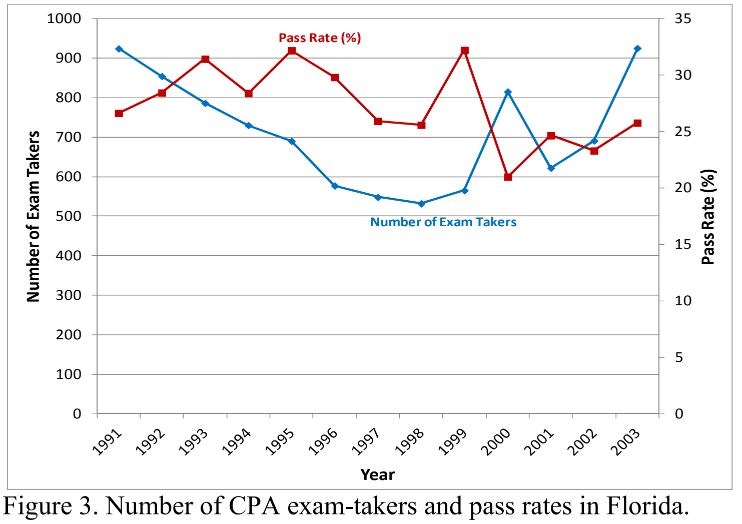


Figure 3. Number of CPA exam-takers and pass rates in Florida.

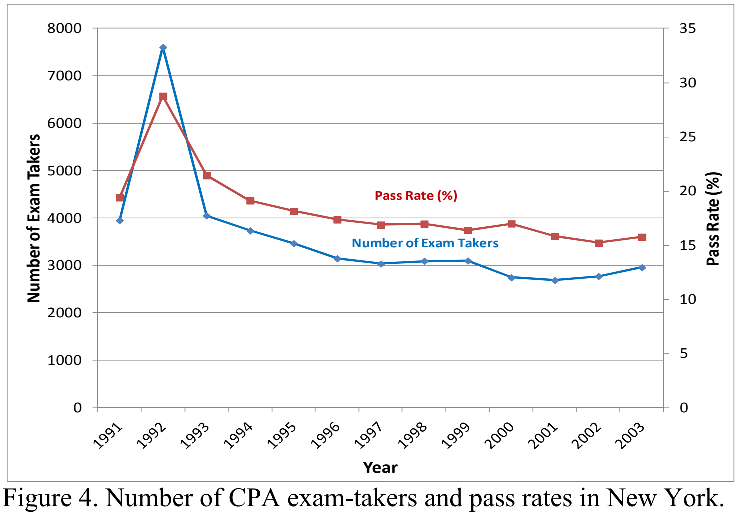


Figure 4. Number of CPA exam-takers and pass rates in New York.

Although Carpenter and Stephenson considered only three states, their results strongly suggest that (1) implementation of the 150-hour rule significantly improved exam pass rates, mitigating the associated reduction in the number of exam-takers; and (2) there was a general decline in the number of exam-takers occurring largely independent of the 150-hour rule.

The first conclusion was strongly validated by Raghunandan et al., who conducted a rigorous analysis of exam performance in *all* CPA jurisdictions.[15] After controlling for SAT scores, accounting credit hours, and enrollment in CPA prep courses, the authors concluded that implementation of the 150-hour rule caused a substantial improvement in exam performance.

A particularly comprehensive study of the CPA case was performed by Metinko and Gray, who did a careful statistical analysis of all transitions of educational requirements in all jurisdictions between 1998 and 2008—from 120 hours to 150 hours and, in some cases, from 150 hours to the 120/150-hour hybrid model.[16] This analysis showed conclusively that the observed decrease in the number of CPA exam-takers was *not due to the 150-hour requirement*. Specifically, there was no statistically significant correlation between the 150-hour requirement and the number of CPA exam candidates. To cite just one of many examples of data from the study: 8 jurisdictions never enacted the 150-hour requirement during the period 1998 to 2008. These constitute 15% of all jurisdictions; and, *despite no change in the exam requirements*, they experienced about 20% of the total decline in exam-takers—a clear indicator that the decline was independent of the requirement. In seeking alternative explanations for this decline, Schroeder and Franz suggested "ignorance about a career in accounting, faulty information about the profession; … negative perceptions of the role of accountants in society; … decreased salary levels, and the availability of more-attractive career alternatives."[17]

In sum, the case of evolving CPA licensure standards over the past two decades is quite complex. The case has been the subject of numerous studies, and some of their conclusions disagree. Certainly, the CPA case cannot be adequately characterized by citing a single study, as the ASME website has done. Furthermore, the preponderance of evidence suggests that increased educational requirements did not cause a significant decline in CPA licensure but did cause a significant improvement in CPAs' technical preparation for professional service.

4. "The added cost would be a hardship. Committing an additional year to obtain an extra thirty credit hours would be a very significant deterrent for anyone who might otherwise pursue an engineering degree."

Education is generally (and appropriately) considered to be an investment in the future and a primary source of human capital.[18] To the extent that the cost of education constitutes a hardship for any individual, that hardship is typically temporary. A recent study by Georgetown University's Center on Education and the Workforce determined that the median salary of an engineer with a graduate's degree is over 30% higher than that of an engineer with only a baccalaureate degree ($99,000 vs. $75,000).[19] At this salary differential, the cost of one year of graduate study would be offset rather quickly, while the intangible benefits associated with performing a higher level of professional work could be substantial.

5. "Increasing the prestige or status of the profession by raising the bar to access does not contribute to the profession nor serve the public."

After dismissing the relevance of professional prestige, the ASME position paper goes on to say that "Engineers rank high in national polls compared to lawyers and other professionals and therefore there is no need to increase educational requirements to achieve additional prestige." This latter claim contradicts the first, suggesting that *professional prestige is relevant*, albeit not a concern because of the engineering profession's current high rankings.

The internal contradiction notwithstanding, the position paper's claim that engineers rank high in national polls is not supported and may be unsupportable. A recent Harris poll on the prestige of professions and occupations placed engineers in the middle of the pack—above real estate agents, journalists, lawyers, members of Congress, and farmers; but below clergy, police, teachers, military officers, nurses, doctors, scientists, and firefighters.[20]

The 5XME Report more closely reflects the Harris data, noting that "engineering is held in low regard by many people" and attributing the profession's lack of prestige to perceptions that:

- Engineers are replaceable and disposable commodities, not leaders and decision-makers.
- Engineers focus on narrow technological problems, and not broader societal needs.
- Engineers are narrowly educated in scientific and technological disciplines.[9]

In "Engineering for a Changing World," James Duderstadt, President Emeritus of the University of Michigan, reinforces this message, writing that "the engineering profession still tends to be held in relatively low regard compared to other learned professions such as law and medicine. Unfortunately, many global corporations tend to view engineers as disposable commodities, discarding them when their skills become obsolete or replaceable by cheaper engineering services from abroad."[21]

Both 5XME and Duderstadt contradict the ASME position paper's claim that engineers rank high in national polls. More importantly, they identify the principal source of engineers' professional prestige not in *exclusivity*, as the position paper suggests, but rather in the nature of the engineers' work, their status vis-à-vis their employers, and the breadth of their education. These ideas are strongly supported by Freidson's well-established sociological model of professionalism, discussed below.

For its part, ASCE has *never* used professional prestige as a justification for enhanced licensure standards. The word "prestige" does not occur in ASCE's *Vision for Civil Engineering in 2025*.[1] It is used only once in the Civil Engineering Body of Knowledge for the 21st Century—and the context is a refutation of the common claim that licensure "is merely a shallow 'prestige' credential."[3] ASCE has consistently and rigorously justified increased educational requirements for licensure in terms of (1) the future challenges confronting 21st-century engineers, (2) which can best be met by engineering professionals who have fulfilled an appropriately defined body of knowledge, (3) which is defined in terms of clearly articulated outcomes, (4) which cannot be achieved through the current four-year baccalaureate degree. If enhanced prestige is a second-order side effect of enhanced education, then so be it; but professional prestige has never been a goal of ASCE's "Raise the Bar" initiative.

6. "ASME believes that the typical scope of an ABET Accredited bachelor's degree can and has been demonstrated to accommodate technical breadth and flexibility and the intellectual skills necessary for engineering graduates to (1) pass the Fundamentals of Engineering (FE) Examination, (2) successfully complete a four-year internship under a licensed engineer and (3) go on to pass the final Principles and Practices Examination (PE) before being licensed as a Professional Engineer."

In the position paper, this argument is presented as the first point of opposition to "a mandatory, across-the-board requirement of BS+30", and then it is repeated nearly word-for-word as the first point in the Conclusion section. We might reasonably assume that this argument is the ASME Board of Governors' principal point of opposition to enhanced educational requirements for licensure.

In a narrow sense, this point is true and, indeed, self-evident. Without a doubt, the current four-year baccalaureate degree does an adequate job of preparing aspiring engineers to pass the current FE Exam and the current PE Exam. If the purpose of ASCE's "Raise the Bar" initiative were to increase exam pass rates, the position paper's argument would be both logical and compelling. But the purpose of the initiative is *not*, nor has it ever been, to increase pass rates; the purpose is to better prepare engineering professionals to meet the extraordinary challenges of *the future*. As such, the ASME paper's principal point of opposition misses the point entirely.

In defending the status quo as "decreed by tradition and practice," the position paper is saying, in effect, *if it ain't broke, don't fix it*. Yet many individual and institutional voices from across the engineering profession have expressed serious concern that our current educational paradigm is inadequate to meet the challenges of the future. In the 2007 report "Moving Forward to Improve Engineering Education," the National Science Board (NSB) summarized this inadequacy as follows:

> Basic engineering skills (such as knowledge of the engineering fundamentals) have become commodities that can be provided by lower cost engineers in many countries, and some engineering jobs traditionally done in the U.S. are increasingly done overseas. To respond to this changing context, U.S. engineers need new skill sets not easily replicated by low-wage overseas engineers. The problems that have driven engineering—even in recent years—are changing, as technology penetrates more of society. Systems have become more tightly coupled. Engineering thinking needs to be able to deal with complex interrelationships that include not only traditional engineering problems but also encompass human and environmental factors as major components. In addition to analytic skills, which are well provided by the current education system, companies want engineers with passion, some systems thinking, an ability to innovate, an ability to work in multicultural environments, an ability to understand the business context of engineering, interdisciplinary skills, communication skills, leadership skills, an ability to adapt to changing conditions, and an eagerness for lifelong learning. This is a different kind of engineer from the norm that is being produced now."[22]

Given this radically changing context for engineering practice, the NSB concludes that "a continuation of the status quo in engineering education in the U.S. is not sufficient in light of the pressing demands for change."

The NSB's challenge to the adequacy of our current four-year baccalaureate degree is powerfully echoed in the 5XME Report,[9] Duderstadt's "Engineering for a Changing World,"[21] the writings of prominent thinkers like Augustine[7] and Grasso[23], the Body of Knowledge documents published by ASCE[3] and the American Academy of Environmental Engineers,[24] the National Society of Professional Engineers (NSPE) Position Statement No. 1752 (Engineering Education Outcomes),[25] and most importantly, the National Academy of Engineering (NAE) strategic vision report, *The Engineer of 2020*.[26] Even ASME's own *2028 Vision for Mechanical Engineering* observes that "The increased breadth and complexity of modern engineering practice are straining the standard four-year curriculum for engineering education."[27]

In every case, these documents call for more broadly educated engineers who can bring a more holistic approach to problem-solving—engineers who understand systems thinking, business principles, public policy, and leadership; who can communicate effectively and adopt a global perspective; and who display adaptability, entrepreneurial spirit, creativity, and practical ingenuity. How can all of these new competencies be addressed in the already strained four-year engineering curriculum? The most frequent answer is that they cannot—that adequate preparation for professional practice must include additional formal education beyond the baccalaureate degree, and that the baccalaureate degree itself must undergo fundamental change.

The National Academy of Engineering recommends that the B.S. degree should be considered as a pre-engineering or "engineer-in-training" degree, and that the master's degree should become the engineering professional degree.[28] The 5XME Report develops this concept further, recommending that:

- The bachelor's degree should introduce engineering as a discipline, and should be viewed as an extension of the traditional liberal arts degree where education in natural sciences, social sciences and humanities is supplemented by education in the discipline of engineering for an increasingly technological world.
- This bachelor's degree in the discipline of engineering can be viewed as the foundational stem upon which several extensions can be grafted: (1) continued professional depth through a professional master's degree in engineering, and (2) transition to non-engineering career paths such as medicine, law, and business administration.
- The masters degree should introduce engineering as a profession, and become the requirement for professional practice.[9]

This is a compelling vision for the future of engineering education—one that proactively addresses the challenges that lie ahead. It stands in sharp contrast with the complacent defense of the status quo reflected in the ASME position paper.

7. "ASME believes that increasing educational requirements for licensure should not be used as a tool to offset the nominal decrease in graduation requirements for the FPD*…[because] this gradual change over time has resulted in no drop in the national test scores in either examination required for engineering licensure."

The ASME position paper acknowledges that "legislatures and state higher education authorities have reduced the coursework required for a baccalaureate degree from as high as 150 to as low

* First Professional Degree

as 120 semester credits, primarily due to budgetary reasons." But the paper asserts that this decline has not affected engineers' preparation for professional practice because engineering education has become more efficient. "Thanks to the power of computers, slide rules are no longer needed."

The assertion of increased efficiency is difficult to prove or to disprove definitively. Certainly, the availability of modern information technologies has created some curricular efficiencies. In civil engineering, for example, most programs teach fewer classical structural analysis methods than they did thirty years ago. Yet much of this efficiency must certainly be offset by growing requirements for curricular coverage of these new technologies themselves. For example, courses in computer-aided design (CAD), geographic information systems (GIS), building information modeling (BIM) did not exist thirty years ago but are common in civil engineering programs today.

The position paper's claim is also weakened by its use of the FE and PE Exams as the sole measures of educational outcomes. These tools provide reasonably effective measures of technical knowledge; however, because the PE Exam is voluntary and the FE Exam is usually voluntary, these exams test only those individuals who choose to be examined. Thus, for example, students who choose not to take the FE Exam because they have been inadequately prepared are not reflected in published exam pass rates.

More importantly, the FE and PE Exams do not test broader, "softer" professional competencies like systems thinking, business principles, leadership, and practical ingenuity—the very competencies that are driving the "Raise the Bar" initiative. ASME claims that declining credit-hour requirements are not a problem, because they have not adversely affected test scores; ASCE would counter that declining credit-hour requirements *are* a problem, because they leave even less space in an already overburdened four-year curriculum for the new broader knowledge and skills that engineering professionals will need to meet future challenges.

8. "Continuing education is an essential life-long need for engineers, and significant learning is necessary for engineers of all disciplines beyond the studies that qualified them for the FPD. These principles are already incorporated within the present system…."

ASCE certainly concurs with the value of continuing education; however, continuing education cannot be a substitute for the high-quality educational outcomes provided in an ABET-accredited institutional context.

In comparison with traditional four-year engineering degree programs, the Civil Engineering Body of Knowledge calls for greater curricular emphasis on fundamentals (math, basic science, and engineering science), enhanced professional practice breadth (communication skills, business, public policy, globalization, leadership, teamwork, etc.), and greater technical depth in the discipline. All but technical depth are to be attained through the baccalaureate degree. This allocation of outcomes to the baccalaureate and master's degree levels is critical because, even in the future, the baccalaureate degree will continue to be the sole ABET-accredited degree in most engineers' formal education. Thus only the outcomes addressed at the baccalaureate level will be subject to the rigorous quality control provided by the ABET process. Fulfillment of these outcomes could not reasonably be attained through continuing education, because there is no mechanism for ensuring that decentralized continuing education programs will produce the specific outcomes constituting the professional body of knowledge.

9. Due to the federated nature of licensing jurisdictions, some states may adopt the BS+30 and others will not, causing disparities and hindering licensee mobility.

Comity licensure has been a long-standing concern for NCEES; it is certainly not a new issue for implementation of the new Model Law. Indeed, there have *always* been significant variations in licensure standards across jurisdictions (e.g., limitations on structural and seismic practice and variations on continuing education requirements). In response to these variations, NCEES has developed a highly effective system for facilitating licensee mobility while also ensuring that engineers are appropriately qualified to practice in their jurisdictions. NCEES facilitates licensee mobility through its Records Program (including the designation of "Model Law Engineers") and through a well-established set of rules and procedures for managing comity licensure.[29] This same system will apply to the new Model Law and Rules, and there is no reason to doubt that it will continue to work effectively.

It is worth noting that *any* change to the NCEES Model Law will inevitably introduce disparities in licensure requirements across jurisdictions. Thus the position paper's argument above could be used as a justification for never making *any* change to licensure statutes or rules. This sort of inflexibility would be a substantial bar to progress.

10. "There is no clear benefit to requiring the BS+30, but there is considerable cost that will affect both firms and individuals."

Although this point is largely a restatement of arguments made elsewhere in the ASME position paper, it is included here as a separate item because it adds the issue of increased cost to *firms*—i.e., the employers of engineers. This point can hardly be disputed. Engineers with master's degrees earn more than engineers with only baccalaureate degrees; thus if educational standards for licensure are raised, employers are likely to pay more for licensed engineers.

One can certainly argue that better qualified engineers will provide more value to their employers, and so the added cost is warranted. One can also argue that the higher cost of professional engineers will cause firms to more clearly delineate professional and non-professional work; to employ their professional engineers only for critical, high-end work involving the application of discretionary judgment; and to employ larger numbers of lower-paid paraprofessionals to handle most routine tasks. (Duderstadt has provided a compelling argument for this model of workplace organization.[21]) These arguments notwithstanding, the potential for added cost to the firm must be acknowledged.

But is a higher price tag for engineering services necessarily a bad thing? The answer, of course, is a matter of perspective. To the employer, it represents an increased cost of doing business and a potential loss of profits; but to the engineer, it represents increased compensation for a higher level of professional work. And to the student, it may represent a compelling reason for choosing to study engineering.

The firm's perspective, though entirely understandable, is potentially very damaging to the engineering profession. This point can be best explained in the broader context of the Sociology of Professions.

Some Perspectives from the Sociology of Professions

The Sociology of Professions is a multi-disciplinary field of scholarly inquiry that attempts to explain:

- the nature of professionalism and the characteristics of professional work;
- how professions develop, grow, interact, and sometimes wither away;
- how professions operate within a broader economic system; and
- how professions function in societies.

A detailed discussion of the Sociology of Professions is beyond the scope of this paper; however, a few salient points from the well-established work of Abbott, Freidson, and Krause are highly relevant to this discussion.[30,31,32]

According to Abbott, the engineering profession is regarded as inherently weak, because of the corporate setting in which engineering work is typically performed. Because the process of translating engineering designs into physical products requires large amounts of capital, engineers are often dependent on large privately owned organizations. In such organizations, engineering typically represents just one specialty in a much larger division of labor. Consequently, engineers, unlike lawyers and accountants, cannot control the market for their services and generally have not been able to dominate the organizations in which they work.[32]

It is hardly surprising, then, that the professional societies representing manufacturing-oriented engineering disciplines have opposed increased educational requirements for licensure. Historically, these disciplines have been strongly influenced by the commercial industries they serve;[32] and these industries have often opposed engineers' efforts to professionalize, in order to preserve flexibility and obtain technical skills at the lowest possible cost.[31] Abbott notes that industrial corporations typically hire at the baccalaureate level to save money, and then provide in-house training as a means of building their employees' loyalty to the firm, rather than to the profession, while also limiting the employees' transportability. The common claim that market forces, not licensing laws, should determine the need for master's-level education is another reflection of this corporate perspective.

Significantly, industry groups and professional societies associated with manufacturing-oriented engineering disciplines have been most vocal in warning that raising standards for licensure will cause shortages of engineers. These warnings can reasonably be interpreted as attempts to preserve the availability of *low-cost* engineering services. According to Freidson, strong professions typically seek to restrict the number of practitioners by setting rigorous standards for attainment of professional licensure. In contrast, efforts to increase the number of engineering practitioners by resisting higher licensing standards clearly reflect the best interests of industry and not of the engineering profession. In this context, the ASME Board of Governors' efforts to preserve an ample supply of less-educated engineers reflect an industrial rather than a professional perspective.

Conclusions

In this paper, I have examined the key points of opposition presented in the ASME position paper "Mandatory Educational Requirements for Engineering Licensure." This analysis suggests the following conclusions:

- Many of the paper's major points of opposition are seriously compromised by false assertions (Points 1 and 5), internal inconsistency (Point 5), misuse or selective use of statistics (Points 1 and 3), and inadequate measures (Point 7). Several simply miss the point by addressing problems other than the one that ASCE's "Raise the Bar" initiative is intended to solve (Points 5 and 6).

- In defending the status quo, as "decreed by tradition and practice," the ASME position paper is fundamentally complacent. In sharp contrast with the NAE *Engineer of 2020* report, the 5XME report, thoughtful analyses by some of the profession's most respected thinkers, and even ASME's own *2028 Vision for Mechanical Engineering*, ASME's position on licensure fails to address the unprecedented future challenges that will demand unique new competencies of professional engineers.

- In the context of the Sociology of Professions, the ASME Board of Governors' position on licensure reflects an orientation consistent with industries' interest in maintaining a large supply of low-cost engineering talent. This perspective is clearly not in the best interest of the engineering profession, as it will only contribute further to the commoditization of engineering services and the subordination of the engineer's professional authority to a corporate entity.

References

1. Steering Committee to Plan a Summit on the Future of the Civil Engineering Profession in 2025. *The Vision for Civil Engineering in 2025.* Reston, VA: American Society of Civil Engineers, 2007.

2. "ASCE Policy Statement 465: Academic Prerequisites for Licensure and Professional Practice," American Society of Civil Engineers, June 2, 2010. Accessed at http://www.asce.org/Content.aspx?id=8376, January 6, 2012.

3. Body of Knowledge Committee of the Committee on Academic Prerequisites for Professional Practice. *Civil Engineering Body of Knowledge for the 21st Century: Preparing the Civil Engineer for the Future.* Reston, VA: American Society of Civil Engineers, 2004.

4. Curriculum Committee of the Committee on Academic Prerequisites for Professional Practice, "Development of Civil Engineering Curricula Supporting the Body of Knowledge for Professional Practice." American Society of Civil Engineers, December 2006.

5. "Model Law," September 21, 2011, National Council of Examiners for Engineering and Surveying. Accessed at https://ncees.org/About_NCEES/Publications/Publications/Model_Law.php, January 7, 2012.

6. "Mandatory Educational Requirements for Licensure: General Position Paper," American Society of Mechanical Engineers, April 25, 2008. Accessed at http://files.asme.org/asmeorg/NewsPublicPolicy/GovRelations/PositionStatements/14652.pdf, January 5, 2012.

7. Augustine, Norman R. "Re-engineering Engineering: 21st-century needs can't be met with just a four-year degree." *Prism*, American Society for Engineering Education, February 2009, 46-47.

8. "Data for Enrollments," Engineering Workforce Commission, American Association of Engineering Societies. Accessed at http://www.ewc-online.org/data/enrollments_data.asp, January 7, 2012.

9. Ulsoy, A.G., Ed. "Report of the '5XME' Workshop: Transforming Mechanical Engineering Education and Research in the USA." National Science Foundation, Arlington, VA, May 10-11, 2007.

10. Galama, Titus and James Hosek. "U.S. Competitiveness in Science and Technology." RAND National Defense Research Institute, 2008.

11. Carnevale, Anthony P., Ban Cheah, and Jeff Strohl. "Hard Times: College Majors, Unemployment and Earnings - Not all College Degrees are Created Equal," Center on Education and the Workforce, Georgetown University. Accessed at http://cew.georgetown.edu/unemployment/, January 7, 2012.

12. "Licensing that Works – Frequently Asked Questions," American Society of Mechanical Engineers. Accessed at http://www.licensingthatworks.org/FAQs.cfm, January 7, 2012.

13. Carpenter, Charles and E. F. Stephenson. "The 150-Hour Rule as a Barrier to Entering Public Accountancy." *Journal of Labor Research*, Winter 2006, 115-126.

14. Carpenter, Charles G. and Clayton A. Hock. "The 150-Hour Requirement's Effect on the CPA Exam." *The CPA Journal*, New York State Society of CPAs, June 2008. Accessed at http://www.nysscpa.org/cpajournal/2008/608/essentials/p62.htm, January 5, 2012.

15. K. Raghunandan, William J. Read, Clifford D. Brown, (2003) "The 150-hour rule: does it improve CPA exam performance?" *Managerial Auditing Journal*, 18(1), 31-38.

16. Metinko, Teresa R. and Dahli Gray. "Decrease in the Number of People Taking the CPA Exam not due to the 150-Hour Requirement." *American Journal of Business Education*, 3(11), November 2010, 45.

17. Schroeder, N., & Franz, D. "Explaining the decline in CPA candidates." *CPA Journal*, 74(10), 62-66.

18. Saxton, Jim. "Investment in Education: Public and Private Returns," Joint Economic Committee, United States Congress, Washington, D.C., January 2000

19. Carnevale, Anthony P., Jeff Strohl, and Michelle Melton. "What's It Worth: The Economic Value of College Majors. Center on Education and the Workforce, Georgetown University. Accessed at http://cew.georgetown.edu/whatsitworth/, January 7, 2012.

20. Harris Interactive, "Prestige of Professions and Occupations," 2008. Accessed at http://www.marketingcharts.com/topics/behavioral-marketing/most-prestigious-occupations-firefighter-scientist-top-list-10045/harris-interactive-prestige-occupations-august-2009jpg/, January 7, 2012.

21. Duderstadt, James J. "Engineering for a Changing World: A Roadmap to the Future of Engineering Practice, Research, and Education. The Millennium Project, The University of Michigan, 2008. Accessed at http://milproj.dc.umich.edu/publications/EngFlex_report/index.html, January 6, 2012.

22. National Science Board. "Moving Forward to Improve Engineering Education." National Science Foundation, November 19, 2007.

23. Grasso, Domenico, et al. "Dispelling the Myths of Holistic Engineering." *PE*, August/September 2008, 26-29.

24. Environmental Engineering Body of Knowledge Task Force. *Environmental Engineering Body of Knowledge*, American Academy of Environmental Engineers, May 2009.

25. Licensure and Qualifications for Practice Committee, "NSPE Position Statement No. 1752—Engineering Education Outcomes," National Society of Professional Engineers, April 2010. Accessed at http://www.nspe.org/resources/pdfs/blog/EEORPositionStatement1752.pdf, January 7, 2012.

26. National Academy of Engineering. *The Engineer of 2020: Visions of Engineering in the New Century*. Washington, DC: National Academies Press, 2004.

27. ASME Strategic Issues Committee of the Strategic Management Sector, "2028 Vision for Mechanical Engineering: A report of the Global Summit on the Future of Mechanical Engineering." ASME, 2008. Accessed at http://files.asme.org/ICOMES/News/15876.pdf

28. National Academy of Engineering. *Educating the Engineer of 2020: Adapting Engineering Education to the New Century*. Washington, DC: National Academies Press, 2005.

29. "Records," National Council of Examiners for Engineering and Surveying. Accessed at http://www.ncees.org/Records.php, January 7, 2012.

30. Abbott, Andrew. *The System of Professions: An Essay on the Division of Expert Labor*. Chicago: University of Chicago Press, 1988.

31. Freidson, Eliot. Professionalism: The Third Logic—On the Practice of Knowledge. Chicago: University of Chicago Press, 2001.

32. Krause, Elliot A. *Death of the Guilds: Professions, States, and the Advance of Capitalism, 1930 to the Present*. New Haven: Yale University Press, 1999.

Appendix A. American Society of Mechanical Engineers Position Paper, "Mandatory Educational Requirements for Engineering Licensure"

Mandatory Educational Requirements for Engineering Licensure

~

General Position Paper
Approved by the
American Society of Mechanical Engineers (ASME)
Board of Governors
April 25, 2008

Endorsed by:

American Institute of Chemical Engineers (AIChE)

American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)

Executive Board of the ASEE Engineering Deans Council

Illuminating Engineering Society (IES)

Institute of Industrial Engineers (IIE)

International Society of Automation (ISA)

Society for Mining, Metallurgy, and Exploration Inc. (SME)

The Minerals, Metals and Materials Society (TMS)

The Society of Naval Architects & Marine Engineers (SNAME)

Introduction

ASME (American Society of Mechanical Engineers) is a professional organization recognized globally for its leadership in providing the engineering community with technical content and a forum for information exchange. With a membership of more than 127,000 mechanical engineers and allied professionals from around the world, ASME serves this wide-ranging technical community through high-quality programs in continuing education, the development and maintenance of codes and standards, research, conferences and publications, government relations, and various forms of outreach.

ASME endorses lifelong learning and encourages mechanical engineers to pursue graduate degrees in engineering. As the quality of engineering education improves around the world, in order to remain globally competitive, engineers who wish to advance in their careers will need to continue their education either through formal study leading to a degree, or through the various types of continuing education that are offered.

The following organizations, representing more than 300,000 engineers, have endorsed this position statement:

- American Institute of Chemical Engineers (AIChE) representing 40,000 members;
- American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) representing 50,000 members;
- Executive Board of the ASEE Engineering Deans Council
- Illuminating Engineering Society (IES) representing 10,000 members;
- Institute of Industrial Engineers (IIE) representing 15,000 members;
- International Society of Automation (ISA) representing 30,000 members;
- Society for Mining, Metallurgy, and Exploration Inc. (SME) representing 12,000 members;
- The Minerals, Metals and Materials Society (TMS) representing 9,586 members; and
- The Society of Naval Architects & Marine Engineers (SNAME) representing 8,500 members.

Background

In 2006, the National Council of Examiners for Engineers and Surveyors (NCEES) adopted a change to the Model Law for professional engineers to require, after the year 2015, a bachelor's degree plus either 30 additional credits or a master's degree in engineering as a prerequisite for licensure as a professional engineer (BS+30).

NCEES claims that it was motivated to add additional credits due to the decline in university and college requirements for a bachelor's degree in engineering from an average of 144 credits 25 years ago to an average of 128 credits today. NCEES also notes the Department of Labor occupational rating for engineering professions is lower than other professions, including law, medicine, accounting, and architecture due to the diminishing educational requirements.

The First Professional Degree (FPD) in engineering has long been considered to be the degree needed for the practice of engineering. The FPD informs the public and licensing bodies about the minimum requirements that qualify an aspiring professional for practice. Since the 1920s, the FPD in engineering in most regions of the world has been a baccalaureate degree, requiring the equivalent of full time study of approximately four years.

Current engineering baccalaureate degrees typically require courses in mathematics; exact sciences and life sciences; fundamentals and practice of engineering; laboratory and design experience; metrology and experimentation; ethics and professionalism; and selected topics from other disciplines, including the liberal arts and business. Some programs also include industry-based experience in the form of cooperative education or internships.

ASME Position Statement on Bachelor's plus 30 credits (BS+30)

ASME opposes a mandatory, across-the-board requirement of BS+30, beyond the FPD currently decreed by tradition and practice.

ASME believes that the typical scope of an ABET Accredited bachelor's degree can be and has been demonstrated to accommodate technical breadth and flexibility and the intellectual skills necessary for engineering graduates to attain licensure as a Professional Engineer. The steps in achieving that status are: (1) passing the Fundamentals of Engineering Examination, (2) successfully completing a four-year internship under a licensed engineer and (3) passing the final Principles and Practices Examination. Before being licensed as a Professional Engineer, these steps assure that the knowledge, skill and ethical standards expected from a Professional Engineer are attained. Continuing education is an essential to the attainment of licensure just as it is a life-long need for engineers of all disciplines beyond the studies that qualified them for the FPD.

The reason for engineering licensure is to help protect the safety, health and welfare of the public (as stated in the National Society of Professional Engineers Code of Ethics and in the codes of most of the other engineering societies.) Legislation in these matters should be used for the purpose of public well-being only. Increasing the prestige or status of the profession by raising the bar to access does not contribute to the profession nor serve the public. The value and effectiveness of the work that engineers do should be the sole measure of the profession. Professionalism and continuous education across the decades of an engineering career, along with strict adherence to the canons of ethics, is the real foundation of public safety.

ASME believes that increasing educational requirements for licensure should not be used as a tool to offset the nominal decrease in graduation requirements for the FPD. Over the past decades, legislatures and state higher education authorities have reduced the coursework required for a baccalaureate degree from as high as 150 to as low as 120 semester credits, primarily due to budgetary reasons. Yet, this gradual change over time has resulted in no drop in the national test scores in either examination required for engineering licensure. In order to produce such results, the approach to educating an engineer has had to become more efficient. Thanks to the power of computers, slide rules are no longer needed.

We currently have a workable, effective and adaptable system of examinations and supervision in practice that results in highly competent professional engineers. We also have a system of state oversight that can take action against an individual engineer or part of the system that can be demonstrated to have fallen short of professional expectations. If more front-end coursework is the remedy, it should be employed because public safety is at risk due to poorly educated engineers. This is not the case now, nor are we seeing early indicators that it will be the case in the foreseeable future.

The people of the United States are concerned about the nation's capabilities in science, engineering and technology. To compete in the modern technological society and global economy it is imperative that we expand our technologically capable workforce.

However, the low number of engineering students in four-year colleges has been going in the wrong direction nationally, as cited in the statistics* below:

- In 1981, 6.7 percent of degrees awarded were in engineering. In 1984, the figure rose to a high of 7.7 percent. Today it has dropped to 5 percent.
- During the past two decades, part of an era that has been described as science and engineering's greatest period of accomplishment, the numbers of engineers, mathematicians, physical scientists, and geoscientists graduating with bachelor's degrees in the United States have declined by 18%. The proportion of university students achieving bachelor's degrees in these fields has declined by almost 40% during that time.
- The number of engineering doctorates awarded by US universities to US citizens dropped by 23% in the past decade.

The engineering degree is one of the most challenging programs of study that one may undertake at the university and requiring an additional 30+ will make it even more difficult to attract the highly capable students we need to ensure our technological growth. Increasing the professional licensing requirements has the potential to reduce the supply of licensed engineers who are able to practice and therefore reduce our Nation's technological competitiveness.

Technological change is continuous and must be maintained over the typical 40 years of a professional engineering career. Adding an academic year of coursework would say very little about the ability of an engineer to practice today but the added cost would be a hardship. Committing an additional year to obtain an extra thirty (30) credit hours would be a very significant deterrent for anyone who might otherwise pursue an engineering degree.

There is also no evidence to suggest that adding thirty credit hours, which represents a full academic year of upper-level undergraduate coursework or graduate-level coursework, will have a positive impact on the public's health and safety. The fundamental issues affecting the public are already adequately covered under the current educational requirements. We believe that it is misguided to add a year of coursework on the front-end of a professional career as a remedy to a public safety problem that has not been demonstrated. It will discourage students from seeking a career in engineering by significantly adding to the time and cost of their education.

<u>Conclusion:</u>

In conclusion, ASME opposes a mandatory, across the board requirement of BS+30, beyond the FPD currently decreed by tradition and practice, for the following reasons:

- ASME believes that the typical scope of an ABET Accredited bachelor's degree can and has been demonstrated to accommodate technical breadth and flexibility and the intellectual skills necessary for engineering graduates to (1) pass the Fundamentals of Engineering Examination,

(2) successfully complete a four-year internship under a licensed engineer and (3) go on to pass the final Principles and Practices Examination before being licensed as a Professional Engineer.

- Continuing education is an essential life-long need for engineers, and significant learning is necessary for engineers of all disciplines beyond the studies that qualified them for the FPD. These principles are already incorporated within the present system as most states require professional development credit to maintain licensure.
- There is no clear benefit to requiring the BS+30, but there is considerable cost that will affect both firms and individuals (tuition, time off, fees, books, commuting, etc.)
- Due to the federated nature of licensing jurisdictions, some states may adopt the BS+30 and others will not, causing disparities and hindering licensee mobility.
- Engineers rank high in national polls compared to lawyers and other professionals and therefore there is no need to increase educational requirements to achieve additional prestige.
- ASME will continue to review the body of knowledge required for entry level engineers not from the standpoint of professional registration, which has been addressed above, but from the standpoint of the global competitiveness of graduating mechanical engineers.

ASME believes legislating this new barrier to entry into the profession is not in the public's interest and comes at the expense of engineering students, their parents and anyone who employs engineering services.

*Is America Falling Off the Flat Earth, Norman R. Augustine, Chair, Rising Above the Storm Committee, National Academy of Engineering and Institute of Medicine of the National Academies, 2007.

This General Position Paper was approved by the ASME Board of Governors on April 25, 2008.

This page intentionally left blank

Chapter 10

Leadership Lessons Learned in Raising the Bar

Stuart G. Walesh, Ph.D., P.E., Dist.M.ASCE, D.WRE, F.NSPE, *S. G. Walesh Consulting*

Originally published as "The Raise the Bar Initiative: Charting the Future by Understanding the path to the Present—The BOK and Lessons Learned," in *Proceedings of the 2012 Conference of the American Society for Engineering Education*, June 2012.

Raise the Bar Initiative: The BOK and Leadership Lessons Learned

Abstract

This paper, one in the collection of Raise the Bar initiative papers, provides a summary of leadership lessons learned (LLL) from the body of knowledge (BOK) element of the CAP^3 effort. The BOK concept, which first appeared within the initiative in 2001, led to defining the civil engineering BOK as the necessary depth and breadth of knowledge, skills, and attitudes (KSA) required of an individual to enter the practice of civil engineering at the professional level (licensure) in the 21st century. The BOK gradually became synonymous with the need to expand the basic education of civil engineers to include a master's degree or equivalent and to intensify the pre-licensure experience.

The BOK element of the Raise the Bar effort calls for reforming, not refining, the education and pre-licensure experience and as such offers a study in major change. Change LLL described in this paper are conduct scholarly studies, start with vision, expect and deal with set backs, apply a change model, test-drive terminology, function transparently and inclusively, persevere and practice principled compromise, recognize and leverage serendipity, and stand respectfully and thankfully on the shoulders of others.

Given that this paper summarizes LLL primarily from a decade-long major change process, it offers two potentially useful "takeaways" for the reader. The first is an improved understanding of the BOK and the second is ideas about how to lead any change effort.

Keywords – ABET, Body of Knowledge, BOK, change, change model, civil engineering, compromise, immovables, knowledge-skills-attitudes, KSA, leader, leadership lessons learned, LLL, licensure, movables, movers, Raise the Bar, terminology

Introduction

This paper summarizes leadership lessons learned (LLL) as a result of developing the civil engineering body of knowledge (BOK) primarily for use in the U.S. The BOK is defined as the necessary depth and breadth of knowledge, skills, and attitudes (KSA) required of an individual to enter the practice of civil engineering at the professional level (licensure) in the 21st century.[1] It is the foundation of ASCE's Raise the Bar initiative to reform the education and pre-licensure experience of U.S. civil engineers. The BOK has gradually become identified with the need to expand the basic education of civil engineers to include a master's degree or equivalent and to intensify the pre-licensure experience.

This paper's purpose is to offer:

- Improved understanding of the BOK as a result of knowing more about the change process used to develop it. This is the paper's retrospective perspective.

- Ideas for leaders, or potential leaders, about how to affect major change in professional, community, or other areas. This is the paper's prospective perspective.

Review of the Body of Knowledge

The aspirational Civil Engineering BOK[1] may be summarized as follows:

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. Lifelong 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 in a specialized technical area and/or professional practice area related to civil engineering)
E	Portion of the BOK fulfilled through the pre-licensure experience

As illustrated, entry into the practice of civil engineering at the professional level (licensure) requires fulfilling 24 outcomes to the appropriate levels of achievement and doing so by completing a bachelor's degree and a master's degree, or approximately 30 acceptable credits, and acquiring pre-licensure experience. The table is a synopsis of the BOK. For a detailed BOK description, refer to the second edition BOK report,[4] and see Appendix I, Body of Knowledge Outcome Rubric, and Appendix J, Explanations of Outcomes.

Conduct Scholarly Studies

In the context of the Raise the Bar movement, the BOK is first mentioned in the 2001 report *Engineering the Future of Civil Engineering.*[2] While noted in that report, the BOK was neither defined nor developed. However, reform participants decided to explore bodies of knowledge and in, 2003, produced the white paper "Moving Toward a Civil Engineering Body of Knowledge for the 21st Century."[3] Key observations:

- With the exception of engineering, major professions and/or their professional associations (e.g., architecture, Certified Public Accountants (CPAs), law, and Project Management Institute (PMI)) view BOKs as essential for a profession and each has articulated its BOK.

- BOKs typically refer to knowledge and skills and some also include attitudes (e.g., CPA, PMI, architecture).

The reason for sharing this part of the BOK history is to stress the need to include scholarly studies in a major change effort. This is LLL1. The afore-mentioned white paper is just one of many BOK-related scholarly works undertaken by volunteers over the past decade. The results of some of these efforts appear as Appendix A in the second edition of the BOK,[4] and include these topics: attitudes, Bloom's Taxonomy, globalization, humanities and social sciences, public policy, and sustainability. Examples of other BOK-related topics studied over the past decade include accreditation criteria and the accreditation process, the former prohibition against dual-level accreditation, and risk and uncertainty.

Call it "scholarly work" or getting our data and information "ducks in a row," either way those who undertake major change projects need to conduct broad and deep studies. Don't assume too much. "It ain't so much the things that we don't know that get us into trouble," according to humorist Josh Billings, "it's the things we know that just ain't so." Determine what others have done in related efforts, why and how they did it, and what they achieved. Obtain this information not necessarily to mimic others, but rather to learn from their experiences.

The Vision Thing: Start With One

Recall the 1988 U.S. Presidential campaign when candidate George H. W. Bush was reported to have referred to "the vision thing" when asked about moving away from short-term campaign objectives and giving attention to the big picture.[5] While recognizing the importance of "the vision thing," the Raise the Bar process fell short of making optimum use of vision. Consider the following chronology of selected major ASCE documents:

- 2004: *Civil Engineering Body of Knowledge for the 21 Century*[1]

- 2007: *The Vision for Civil Engineering in 2025*[6]
- 2008: *Civil Engineering Body of Knowledge for the 21st Century—Second Edition*[4]
- 2009: *Achieving the Vision for Civil Engineering in 2025*[7]

Ideally, from the BOK perspective, the second and fourth reports, and the vision work they represent, should have been in the first and second position followed by the two BOK reports. That is, the BOK reports and the underlying efforts should have been viewed as means to help achieve Vision 2025. Critics of the Raise the Bar initiative, and especially its foundational BOK element, expressed legitimate concern about the absence of an explicit, over-arching civil engineering vision. Interestingly, ASCE did initiate a vision effort in 2002 but decided to defer it until the National Academy of Engineering completed its "The Engineer of 2020" project.

Consider Vision 2025, which follows:[6]

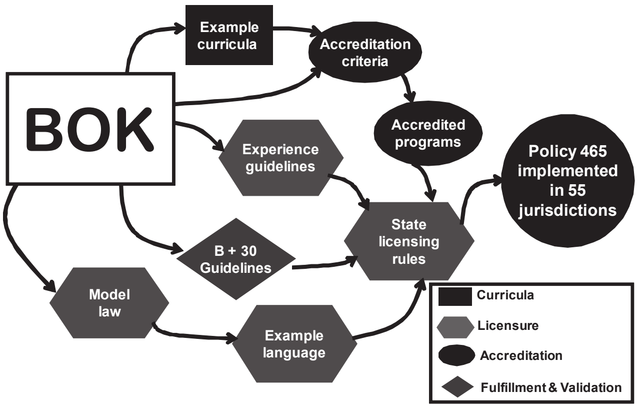
Entrusted by society to create a sustainable world and enhance the global quality of life, civil engineers serve competently, collaboratively, and ethically as master:

- **planners, designers, constructors, and operators of society's economic and social engine—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.**

Achieving this aspirational and comprehensive vision will require major efforts within civil engineering, including reform in the preparation of civil engineers, that is, in their education and pre-licensure experience. Fortunately, the sub-optimal timing of the ASCE visioning and Raise the Bar efforts did not have a major negative impact on either. Nevertheless, LLL2 is start with a vision, that is, major change efforts are much more likely to be successful if aligned with an explicit vision for the relevant organization and its stakeholders.

Expect and Deal With Set Backs

Engineers know how to plan—how to identify and link the steps needed to achieve an objective. Consistent with that tradition, Raise the Bar leaders developed a plan, part of which is shown in the following figure, to develop the BOK and use it to achieve the ultimate objective which is to implement ASCE Policy Statement 465 in 55 licensing jurisdictions.



Simply stated, engineers strive to effectively and efficiently achieve their objective. However, as observed by Scottish poet Robert Burns, and translated into standard English, "The best-laid schemes of mice and men go often askew" (Wikipedia 2011).

"Going askew" happened often during development and initial use of the BOK. For example, the Committee on Academic Prerequisites for Professional Practice (CAP^3) secured an opportunity to speak to members of the Engineering Deans Council (EDC) during their luncheon at the 2003 ASEE conference. And I was the designated speaker. Shortly after beginning to speak, I realized that the audience was much more interested in eating the food they were being served than in listening to engineering education reform ideas I was serving. My inability to engage the audience was a personal set back. This setback resulted, in part, from the assumption that this group of education leaders would naturally be interested in an education reform idea, although not necessarily be open to it.

Much more seriously, the reform effort subsequently experienced some related set backs. In 2006, the EDC formally opposed removing the prohibition on dual-level accreditation.[8] Furthermore, in 2010 the Executive Committee of the EDC stated "we do not believe that the NCEES [National Council of Examiners for Engineering and Surveying] current Model Law (August 2009) that would require a bachelor's degree in engineering plus either 30 additional credits or master's degree in engineering as a prerequisite for licensure as a professional engineer (BS + 30) is in the best interests of our students, the engineering education enterprise, or the engineering education profession in the U.S."[9]

The preceding is shared in this paper to emphasize that personal and group set backs are inevitable when major change is undertaken. Set backs need not become road blocks—learn from them. View set backs as opportunities to examine and possibly revisit assumptions and revise the tactics needed to move the change effort forward. To continue the EDC account, the Raise the Bar effort persisted and, in 2007, ABET eliminated the prohibition on dual-level accreditation and the Model Law changes stand. In summary, LLL3 is expect and deal with set backs.

Apply a Change Model

Change leaders must recognize natural, initial, and widespread resistance to major changes and plan accordingly. Nicole Machiavelli, the Italian politician and writer, explained opposition to change as follows:[10]

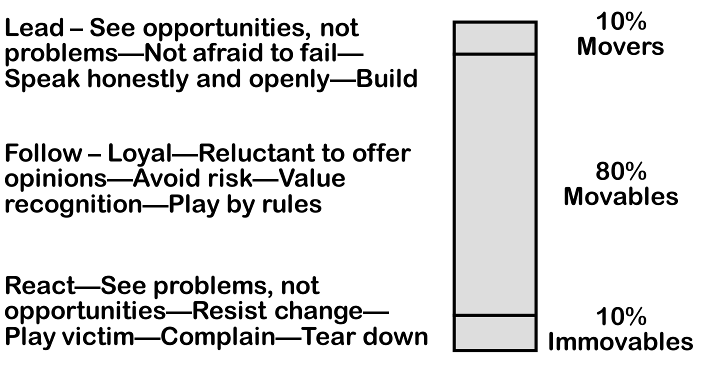
There is nothing more difficult to plan,
more doubtful of success, nor more dangerous to manage
than the creation of a new system.
For the initiators have the enmity of all who would profit
by the preservation of the old institutions and
merely lukewarm defenders in those who would gain
by the new one.

Note, in particular, his mention of the initial "enmity" of many who oppose change contrasted with the only "lukewarm defenders" of change. Effecting major change is difficult. Nevertheless, the leader in us wants change—we are dissatisfied with the present situation and can see a better one.

Why do many of us resist change? The possibility of change causes each of us to compare the way things are to the way things could be. We contrast the familiar and comfortable with the unfamiliar and uncomfortable. I believe that most of us, at the cognitive level, can see and weigh the "pros" and "cons" of a proposed change, especially if thoughtfully presented. However, even if the "pros" outweigh the "cons" at the cognitive level, we fear, at the emotional level, how we are going to get from here to there. The unknown trip is scary! Therefore, when faced with change, we often revert to fear and other emotions, not reason.

Given the challenges of change, an operational change model that recognizes basic human behaviour can help us lead change. Presented here is a simple model[11] that is consistent with the BOK experience. Applying a change model is LLL4.

Begin by putting members of the group that would be affected by the proposed change into one of the three categories illustrated in the following figure, that is, the movers, the movables, and the immovables.[12]



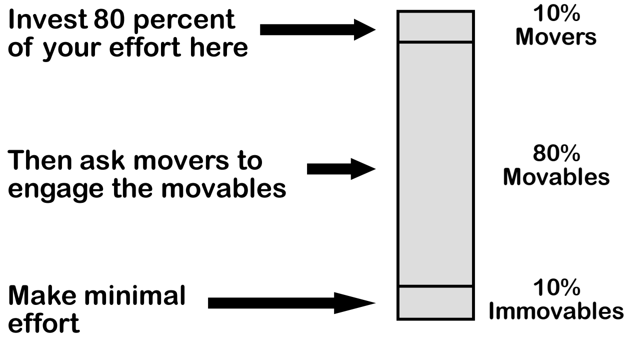
Consider each of the three categories:

- The movers, comprising roughly ten percent, are predisposed to change and to leading change.
- The movables, the large approximately eighty percent component, are predisposed to follow. They can be convinced of the need for change.

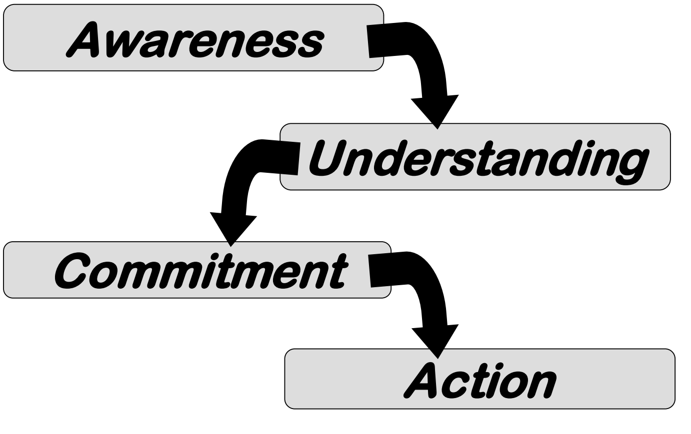
- The immovable, the remaining ten percent, tend to react and do so negatively. They are not likely to seriously consider any arguments for change. As someone said, "Some minds are like concrete, thoroughly mixed up and permanently set."

An alternative set of three terms, having essentially the same meaning, is accepters, undecided, and rejecters.[13]

A way to work with an organization in which we want to lead change is, as shown in the following figure, to devote most of our efforts to communicating the vision and initial strategy and tactics ideas to the movers. Ask them to thoughtfully consider our ideas, refine them, and hopefully, in principle, accept them. This could require a major effort by us and them and considerable elapsed time. However, in engaging the movers, we are working with a growing, core group of forward-looking individuals. Ask the now hopefully-committed movers to, in turn, communicate with and engage the movables, possibly following the cascade concept described below. Identifying and focusing on movers (or acceptors) was used in developing and beginning to implement the BOK.



Now consider the cascading awareness-understanding-commitment-action process shown in the following figure and how to use it, initially with the movers and then with the movables. It cascades in that it flows from the top to the bottom while the number of participants becomes smaller—sometimes dramatically so—as the process proceeds. However, even so, the number of individuals remaining at the critical, last or action level is often adequate to effect change.



As noted earlier and illustrated with typical statements, on becoming aware of a possible change, many of us react in a mostly emotional knee-jerk fashion. We, as change leaders, should anticipate and gracefully tolerate knee-jerk reactions. Simply ask for understanding of what is being proposed and the reasons for it, don't necessarily ask for support. Some of the knee-jerkers will show us that courtesy. And, on understanding, a portion of them will commit. Finally, for some, that commitment will lead to action needed to advance the change effort.

AH HA! is another way of presenting the cascade process. The first "A" represents awareness, that is, we learn of a proposed change. The first "H" represents head, that is, some will understand the proposed change and its features. The second "H" is for heart in that some of those who understand will commit to supporting the change. The second "A" represents action meaning that some of the committed will act to effect the proposed change.

Test-Drive Terminology

The strategy and tactics employed to achieve a goal or vision should include sensitivity to how the various stakeholders might respond to the language used to describe the change. Words that seem appropriate to change leaders may be misunderstood or even viewed negatively by others. This is exactly what happened early in Raise the Bar effort and the subsequent desire to find acceptable terminology led to increased emphasis on using the term BOK. Reflect on Mark Twain's thought, "The difference between the right word and the almost right word is the difference between lightning and the lightning bug."

In October 1998 the ASCE Board of Direction adopted Policy Statement 465, which began as follows: "The ASCE supports the concept of the master's degree as the First Professional Degree (FPD) for the practice of civil engineering at the professional level."[1] The intent was to gradually move toward a vision of more formal education for tomorrow's U.S. civil engineers. Unfortunately, the wording was interpreted by some practicing U.S. civil engineers to mean that their bachelor's degree was not a professional degree.

Partly because of that negative interpretation, the policy was re-worded in 2001 to read: "The American Society of Civil Engineers (ASCE) supports the concept of the master's degree or equivalent (MOE) as a prerequisite for licensure and the practice of civil engineering at the professional level."[1] This version seemed to diminish some of the initial negative reaction while continuing to support the vision of more formal education for U.S. civil engineers.

In 2004, the policy was refined to begin as follows: "The ASCE supports the attainment of a body of knowledge for entry into the practice of civil engineering at the professional level."[4] Now the specification of a master's degree or equivalent was replaced with attainment of a BOK. Finally, the acceptable terminology was achieved. Accordingly, in spite of the preceding missteps, the ASCE-led effort to reform the education and pre-licensure experience of U.S. civil engineers is moving forward. The BOK concept has proved to be an interest shared by both academics and practitioners and a common and productive forum for these two groups; both have a stake in the BOK.

The essence of LLL5: After drafting a goal or vision and beginning to work on the implementation strategy and tactics, "test drive" the language and terminology before moving into wide public exposure. For example, circulate draft text, make trial presentations, and/or use focus groups.

Function Transparently and Inclusively

From the outset, in the spirit of communicate-communicate-communicate, the Raise the Bar movement, as exemplified by the process used to develop and begin the implement the BOK, has practiced transparency and inclusivity. More specifically, leaders of the reform movement:

- Issued agendas and minutes of meetings to anyone who expressed interest.

- Captured important decisions and products, and underlying process, in writing in the form of the aforementioned minutes, email discussions, major reports,[1, 2, 3, 4] and conference presentations and proceedings. Major reports were offered, at no cost, on the "CE Body of Knowledge" and "Competency-Raise the Bar" portions of the ASCE website.

- Established, for major committees, Corresponding Members status which was available to anyone who expressed interest. For example, the committee that produced the second edition of the BOK had 15 formal members and 51 Corresponding Members all of whom received meeting agendas and minutes and were invited to participate in meetings (mostly conference calls) and weigh in on any issue or topic.

- Invited critics of the BOK and/or the process being used to develop and implement it to elaborate on their views, participate in meetings, and join committees and task groups. In at least several situations, the invitations were accepted, the individuals became actively involved, and they influenced and contributed to the BOK effort.

- Sought new active participants. CAP^3 and BOK leaders repeatedly scanned the group of individuals in the academic and practitioner sectors who were not actively involved in the reform effort but might, based on their supportive or contrary views, be interested in joining. As opportunities arose, many individuals were invited to formally join the effort. For example, of the 15 members of the second BOK committee, only one was a carryover from the first 13-member committee.

- Met "anywhere" with "anyone." If at all feasible, CAP^3 members, including members of the BOK committees, met with, made presentations to, and interacted with any person or group expressing interest.

In summary, regardless of the change that is being advocated, LLL6 is function transparently and inclusively. By applying LLL6, the core group tends to grow and does so by attracting engaged individuals with diverse KSAs which, in turn, generates more ideas and leads to better decisions.

Persevere and Practice Principled Compromise

Recall LLL3, expect and deal with set backs. When experiencing set backs, especially major ones like the examples provided in discussing LLL3, we are tempted to lower or compromise our vision. Using the BOK as an example, some might argue that its aspirational aspects should be diminished, that is, "shoot lower," as in replacing "master's degree or equivalent" with more continuing education. Or consider the overall Raise the Bar effort. In frustration, almost anyone could argue that the envisioned end point of implementing ASCE Policy Statement 465 in all 55 licensing jurisdictions is not realistic.

As compelling as such compromises might be in the short run, a more credible, courageous, and fruitful long-term approach is to compromise on or otherwise adjust the means being used to achieve the vision. Therefore, LLL7 is persevere and practice principled compromise.

Recognize and Leverage Serendipity

Just as major unexpected set backs occur in a major change effort, such as the Raise the Bar initiative, so do major unexpected boosts. Celebrate and leverage them.

Recall that the first edition BOK was published in 2004.[1] Development of the BOK and advancement of the Raise the Bar effort were buoyed up by two U.S. National Academy of Engineering studies whose results were published in 2004[14] and 2005.[15] The report of the first study concluded that "...if the engineering profession is to take the initiative in defining its own future, it must...agree on an exciting vision for the future; transform engineering education to help achieve the vision..." This conclusion clearly indicated that the time had arrived for all of U.S. engineering to reform, not refine, the preparation of tomorrow's engineers.

The second study's report concluded: "...it is evident that the exploding body of science and engineering knowledge cannot be accommodated within the context of the traditional four-year baccalaureate degree." The report recommended that the baccalaureate degree be considered as a pre-engineering or Engineer-in-Training degree and the master's degree be regarded as the professional degree. This strongly reinforced, based on all engineering education, the rationale statement within ASCE Policy Statement 465 which says that the baccalaureate degree is "becoming inadequate for the professional practice of engineering."

Beginning in 2005, Raise the Bar participants made appropriate reference to the NAE findings and also cited reform support and actions offered by other organizations such as:

- ABET: Approved changes to the Program Criteria for Civil and Similarly Named Engineering Programs (civil engineering program criteria) and approved changes to General Criteria for Masters Level Programs (masters level criteria).[4]

- AAEE: Published *Environmental Engineering Body of Knowledge*[16]

- NCEES: Modified the licensure Model Law to require education beyond the bachelor's degree[17]

- NSPE: Adopted supportive Professional Policy No. 168, Engineering Education Requirements,[18] which supports formal education beyond the bachelor's degree and Position Statement No. 1752, Engineering Education Outcomes,[19] which advocates that the education of engineers who on are a licensure track include basics of leadership, risk and uncertainty, project management, public policy, business, and sustainability principles.

Those who lead change are typically optimistic. Accordingly, they embrace LLL8: Recognize and leverage serendipity.

Stand—Respectfully and Thankfully—on the Shoulders of Others

Regardless of a change effort's vision and/or the energy of its leadership, the scholarship that is integral to that effort (see LLL1) will inevitably reveal that the change initiative builds on the work of others. This is LLL9, and the last lesson learned during the development and initial implementation of the civil engineering BOK. Be respectful of and thankful for the earlier—sometimes decades or more—work of others.

Consider these examples which are relevant to the Raise the Bar program:

- 1918 Mann report:[20] Offer a common curriculum for the first two or three years, give more attention to values and culture, simultaneously teach theory and practice, and promote cooperative education.

- 1928 Wickenden report:[21] Limit engineering education to four years, reduce technical specialization at the undergraduate level, and add economics and liberal arts.

- 1955 Grinter report:[22] Increase emphasis on science and mathematics.

- 1965 Walker report:[23] Strengthen liberal education, base engineering curricula on engineering science, improve analysis-synthesis-design ability, encourage industry-government-university cooperation, make the bachelor's degree a general engineering degree, and establish the "master's degree in an engineering specialty" as the "basic professional degree for engineers."

- 1985 NAE report:[24] Offer broad engineering education, stronger non-technical education, exposure to realities of the work world, personal career management, and greater management skills.

- 1974-1995 ASCE Education Conferences: The 1995 conference recommended professional degrees (more formal education), integrated curriculum, faculty development, and practitioner involvement.

Other Lessons Learned

This paper highlights nine LLL as a result of contemplating the process used to develop and begin the implementation of the civil engineering BOK. The LLL reflect insights provided by a decade of various Raise the Bar activities and the author's other change experiences. Clearly, choices were made in writing this paper in that other LLLs could have been shared. In the spirit of trying to be helpful, the following LLLs are noted, but not discussed:

- Proactively plan, conduct, and follow-up on meetings.

- Meet frequently, mostly electronically, as needed to maintain the change group's momentum.

- Encourage individuals to "put in writing" their ideas, concerns, suggestions, objection support—partly to encourage them to more thoroughly articulate their thoughts and partly to facilitate sharing and discussion.

- Seek participants who have personal and interpersonal skills such as time management, goal setting and achieving, organizing, delegating, listening, writing, and speaking.

- Practice honesty (tell the truth) and integrity (keep promises).

Summary of Lessons Learned

As noted at its outset, this paper summarizes LLL from or illustrated by the decade-long Raise the Bar effort with emphasis on the process used to develop and begin to implement the civil engineering BOK. The hope is that these LLL will provide readers with an improved understanding of the BOK and/or offer ideas about how to lead any change effort. The nine LLL are:

1. Conduct scholarly studies

2. Start with a vision

3. Expect and deal with set backs

4. Apply a change model

5. Test-drive terminology
6. Function transparently and inclusively

7. Persevere and practice principled compromise

8. Recognize and leverage serendipity

9. Stand respectively and thankfully on the shoulders of others

A review of this list, informed by the discussions in this paper, may suggest that the LLL are mostly common sense. Perhaps, at least in that each LLL is easy to understand. However, experience teaches that common sense does not necessarily translate into common practice. Knowing something and using it are not the same. Knowledge is not power; knowledge applied is power. Applying the LLL offered in this paper requires self and organizational discipline. In my view, the Raise the Bar effort has embraced discipline and will continue to do so.

Bibliography

1. American Society of Civil Engineers. 2004. *Civil Engineering Body of Knowledge for the 21st Century: Preparing the Civil Engineer for the Future,* Reston, VA, January.

2. American Society of Civil Engineers. 2001. *Engineering the Future of Civil Engineering,* ASCE, Reston, VA.

3. American Society of Civil Engineers. 2003. "Moving Toward a Civil Engineering Body of Knowledge for the 21st Century." Task Committee on Academic Prerequisites for Professional Practice, ASCE, Reston, VA.

4. American Society of Civil Engineers. 2008. *Civil Engineering Body of Knowledge for the 21st Century: Preparing the Civil Engineer for the Future – Second Edition,* Reston, VA, January.

5. Wikipedia 2011a. "The Vision Thing." http://en.wikipedia.org/wiki/Vision-thing.

6. American Society of Civil Engineers. 2007. *The Vision for Civil Engineering in 2025,* ASCE, Reston, VA.

7. American Society of Civil Engineers. 2009. *Achieving the Vision for Civil Engineering in 2025: A Roadmap for the Profession,* ASCE, Reston, VA.

8. ASEE, Engineering Deans Council. 2006. "Resolution of the ASEE Engineering Deans Council Regarding Reversing the Current Prohibition on Dual-Level Accreditation," September 21.

9. Galloway, K. F., Chair, ASEE Engineering Deans Council. 2010. "Letter to D. J. Soukup, ASME," July 8.

10. Machiavelli, N. 1980. *The Prince.* Translated by E. R. P. Vincent, New American Library, New York, NY. (Originally published in 1537).

11. Walesh, S. G. 2012. *Engineering Your Future: The Professional Practice of Engineering,* John Wiley & Sons, Hoboken, NJ and ASCE Press, Reston, VA.

12. Annunzio, S. with J. Liesse. 2001. *eLeadership: Proven Techniques for Creating an Environment of Speed and Flexibility in the Digital Economy,* The Free Press, New York, NY.

13. Brenner, R. 2009. "Letting Go of the Status Quo: The Debate," *Point Lookout,* e-newsletter, December 30.

14. National Academy of Engineering. 2004. *The Engineer of 2020: Visions of Engineering in the New Century,* NAE, Washington, DC.

15. National Academy of Engineering. 2005. *Educating the Engineer of 2020: Adapting Engineering Education to the New Century,* NAE, Washington, DC.

16. American Academy of Environmental Engineers. 2009. *Environmental Engineering Body of Knowledge,* AAEE, Annapolis, MD, May.

17. National Council of Examiners for Engineering and Surveying. 2011. *Model Law,* August.

18. National Society of Professional Engineers. 2007. "Professional Policy No. 168 – Engineering Education Requirements."

19. National Society of Professional Engineers. 2010. "Position Statement No. 1752 – Engineering Education Outcomes."

20. Mann, C. R. 1918. *A Study of Engineering Education,* prepared for the Joint Committee on Engineering Education of the National Engineering Societies, New York, NY.

21. Wickenden, W. E. 1929. *Report of the Investigation o f Engineering Education,* The Society for the Promotion of Engineering Education.

22. Grinter, L. (Chairman). 1955. *Report on the Evaluation of Engineering Education,* American Society for Engineering Education, Washington, DC.

23. Walker, E. A. 1965. *Goals of Engineering Education,* American Society for Engineering Education, Washington, DC.

24. National Resource Council. 1995. *Education of Architects and Engineers for Careers in Facility Design and Construction,* National Academy Press, Washington, DC.

This page intentionally left blank

About the Contributors

Richard O. Anderson, P.E., Dist.M.ASCE

Richard O. Anderson is the Principal Engineer of Somat Engineering, Inc. in Detroit, MI. Prior to this position Mr. Anderson was the President of Somat for several years and previously was the Senior Vice President of another consulting engineering firm. Mr. Anderson is a licensed professional engineer in Michigan and several other north-central states.

Mr. Anderson has been a consulting engineer for over 41 years, specializing in deep foundations, earth retention systems, ground modification, and groundwater analysis. He has been involved with over 10,500 projects, primarily in the Midwest, although he has worked from coast to coast and in several foreign countries. He has also served as an expert witness in over 50 disputes, including testimony in both federal and state courts.

Mr. Anderson has been very active in engineering education as a practitioner. He has served on six professional advisory boards for departments of civil engineering and colleges of engineering. Mr. Anderson served the Accreditation Board for Engineering and Technology (ABET, Inc.) in many roles including Program Evaluator, Team Chair, Board of Directors, and in the President's position. In these roles, he acted as an ABET representative on many foreign visits to assist in developing accreditation systems in those countries. He is currently serving as the President of the ABET Foundation, Inc.

Mr. Anderson has also been very active in ASCE on the local and national levels. He served on the Curricula and Accreditation Committee, and was Chair of the Educational Activities Committee. In that latter role, he co-authored the initial version of ASCE Policy Statement 465 ("First Professional Degree") that has evolved into the guiding document for the ASCE Raise the Bar" effort. He served on the Task Committee and the subsequent Committee on the Academic Prerequisites for Professional Practice, and was Chair of the Body of Knowledge Committee that developed the Second Edition of the Civil Engineering Body of Knowledge. He is currently serving as the Chair of the Civil Engineering Program Criteria Task Committee that is examining the possible revision of the ABET Civil Engineering Program Criteria in light of the Second Edition of the Body of Knowledge.

In addition to serving as ABET President, Mr. Anderson has also served as President of the Association of Soil and Foundation Engineers (ASFE). Mr. Anderson's honors include: Distinguished Member of ASCE; Fellow of ABET, ASCE, and ASFE; ASCE President's Medal; Chi Epsilon Chapter Honor Member at University of Michigan and Lawrence Technological University; the ASCE Edmund Friedman Professional Recognition Award; the George K. Wadlin Award of the Civil Engineering Division of ASEE; the ASCE Excellence in Civil Engineering Education (ExCEEd) Leadership Award; member of the Academy of Civil and Environmental Engineers of Michigan Technological University; Civil Engineer of the Year Award from the ASCE Southeastern Michigan Branch, and the Michigan Section of ASCE; the Outstanding Service Award by ADSC: The International Association of Foundation Drilling; and membership in both Chi Epsilon and Tau Beta Pi honorary societies.

Mr. Anderson served in the U. S. Army in South Vietnam as an artillery forward observer, and received the Bronze Star medal and the Purple Heart with Oak Leaf Clusters.

Michael J. Chajes, Ph.D., P.E., M.ASCE

Michael J. Chajes is a Professor of Civil and Environmental Engineering at the University of Delaware (UD). Dr. Chajes is also a registered Professional Engineer in Delaware, and served on the state's Professional Engineering Registration Board from 1995 to 2000. In 2010, Dr. Chajes was named Delaware Engineer of the Year and was also awarded a UC Davis College of Engineering Distinguished Engineering Alumni Medal.

Dr. Chajes was an undergraduate civil engineering student at the University of Massachusetts at Amherst and graduated with honors in 1984. After receiving his bachelor's degree, he attended the University of California at Davis and received his M.S. in 1987 and his Ph.D. in 1990. While at Davis he was twice awarded the University's Outstanding Graduate Student Teaching Award.

Dr. Chajes began his academic career in 1990 when he joined the faculty at the University of Delaware as an Assistant Professor of Civil and Environmental Engineering. He was promoted to Associate Professor in 1996 and to Professor in 2002. He served as Acting Associate Chair of Civil and Environmental Engineering in 1996, and as Associate Chair of Civil and Environmental Engineering from 1998-2001. In July of 2001, Dr. Chajes was appointed Chair of the Department of Civil and Environmental Engineering, a position he held through September of 2007. In October of 2007 Dr. Chajes was appointed as Interim Dean of the College of Engineering, and in July of 2008, Dr. Chajes was appointed Dean of the College of Engineering, a position he held through June of 2011.

Dr. Chajes is a member of the American Society of Civil Engineers (ASCE) and the American Society for Engineering Education (ASEE). Within ASCE, he was a member of the Department Heads Council Executive Committee from 2002-2007, serving as Chair from 2005-2007. He served as a member of the task committee that planned the summit on the "Future of the Civil Engineering in 2025" (held in 2006), and was on the Government Affairs Committee. Within ASEE he was served on the Engineering Deans' Council and the Public Policy Committee.

As a faculty member at the University of Delaware, Dr. Chajes has taught numerous classes in the areas of structural analysis and structural design. He was instrumental in the development of the college's Introduction to Engineering class that is now taken by all freshmen in engineering. He has supervised 40 M.S. students ad 5 Ph.D. students while at UD, as well as over 50 undergraduate research students. Finally, he has provided administrative leadership at UD through his 10 years of service as both Dean of the College of Engineering and Chair of the Civil and Environmental Engineering Department.

In terms of research, Dr. Chajes' areas of specialization are bridge testing, evaluation, and rehabilitation. He is an affiliated faculty member of the Center for Innovative Bridge Engineering, the Center for Composite Materials, and the Delaware Transportation Center. He has served as PI or co-PI on more than $5M of research grants funded by the National Science Foundation, the National Academy of Sciences, the Federal Highway Administration, the National Cooperative Highway Research Program, the Delaware Department of Transportation, and several industrial groups and foundations. Based on this research, Dr. Chajes has published more than 100 papers and presented his work through more than 70 talks in the US and abroad.

Michael J. Conzett, P.E., BCEE, M.ASCE

Michael J. Conzett is a Vice President and Senior Project Manager with HDR, Inc. in Omaha, Nebraska. He has 35 years experience in the study of the impacts of chemical contaminants on soil and ground water and the design and implementation of remediation systems. He received a BS degree in Civil Engineering and an MS degree in Sanitary Engineering, both from Iowa State University. He is a licensed professional engineer in Nebraska, Iowa, and Ohio. Mr. Conzett is an Iowa Certified Groundwater Professional and a Board-Certified Environmental Engineer in the American Academy of Environmental Engineers, serving as its Nebraska state representative.

Mr. Conzett began his professional career in 1978 as a research project engineer for the Procter & Gamble Co. in Cincinnati, Ohio where he studied the fate and effects of consumer products and their ingredients on the environment and on water/wastewater treatment systems. With HDR from 1984 to the present, he has specialized in the execution and management of large environmental planning and engineering projects, as well as hazardous, toxic, radioactive waste restoration projects for public and private sector clients. He has successfully managed large projects to assess the degree and extent of contamination resulting from hazardous waste management practices.

Mr. Conzett's service to the engineering profession includes membership and leadership roles in the American Society of Civil Engineers (ASCE), Water Environment Federation (WEF), and Society of American Military Engineers (SAME). In addition, he has served on the Nebraska Board of Engineers and Architects since 2003. He is currently beginning his third term and has served as chairman from 2007 to 2008 as well as on several board committees.

As an extension to his Nebraska Board service, Mr. Conzett has served for the past ten years as a member of the National Council of Examiners for Engineering and Surveying (NCEES). Within that organization he has been a member of the Uniform Procedures & Legislative Guidelines Committee and Committee on Examination Policy & Procedures, a consultant for the Advisory Committee on Council Activities, and the past chair of the Bachelor's Plus 30 and Engineering Education Task Forces. Mr. Conzett was awarded the NCEES Central Zone Distinguished Service Award in 2011. He is currently a member the NCEES Board of Directors as its Central Zone Vice President (2012-2014) and is scheduled to be a candidate for President-Elect of NCEES in 2014.

Mr. Conzett is proud of his involvement as a volunteer in community and civic organizations such as the Omaha Symphony and the City of Ralston, Nebraska Planning Commission. He was a member of the 1993-1994 Leadership Omaha class and was named one of the Omaha Jaycee's Ten Outstanding Young Omahans in 1994. A frequent blood platelet donor, he received the American Red Cross Lambert Achievement Award in 2012.

Kenneth J. Fridley, Ph.D., F.ASCE

Kenneth J. Fridley is a second-generation engineering educator. Since 2003 he has served as Professor and Head of the Department of Civil, Construction and Environmental Engineering at the University of Alabama. He also is serving as Director of the University of Alabama's Center for Sustainable Infrastructure. Previous to his appointment at the University of Alabama, Dr. Fridley served on the faculty at Purdue University, the University of Oklahoma, Washington State University and the University of Nevada, Las Vegas (UNLV). While at UNLV, Dr. Fridley served as Associate Dean of Research and Information Technology for the Howard Hughes College of Engineering from 2001 to 2003. Dr. Fridley received his B.S. in civil engineering from Washington State University in 1985, his M.S. in architectural engineering from the University of Texas at Austin in 1986, and his Ph.D. in civil engineering from Auburn University in 1990.

Dr. Fridley has been recognized as a dedicated educator throughout his career and has received several awards for his teaching efforts, including the ASCE Excellence in Civil Engineering Education (ExCEEd) Leadership Award in 2010. He was part of a team that developed a suite of interactive, internet-based educational courseware to aid in the teaching and learning of structural wood design. At the University of Alabama, Dr. Fridley has led efforts to establish several new programs including a departmental Scholars program allowing highly qualified students and accelerated program to earn their MSCE in addition to their BS degree, the interdisciplinary ideaLAB promoting innovation in engineering, a new Bachelor of Science degree program in construction engineering, and the cross-disciplinary MSCE/MBA and MSCE/JD dual-degree programs. Fridley has advised 28 masters and doctoral students to completion. His former students have moved into leadership positions in industry, public service, and academia.

Dr. Fridley is considered to be a leading expert in the area of engineered wood construction, performance, time-dependent behavior, and hazard mitigation. He has published over 150 technical papers in the areas of wood materials and engineering, hazard performance and mitigation, and engineering education. He is also the corresponding author of the leading wood engineering design textbook, *Design of Wood Structures*, which is now in its sixth edition and used widely both in the academic and professional markets. Dr. Fridley has been personally involved in over $2.5M is externally funded research that has been supported by a wide variety of federal, state and industrial sources. Much of Dr. Fridley's research has directly impacted the civil engineering profession and resulted in changes in national design specifications and codes. Currently, Dr. Fridley is serving on the executive steering committee for the National Science Foundation-funded Northern Gulf Coastal Hazard Collaboratory, a research and outreach partnership program between multiple universities in Alabama, Mississippi and Louisiana.

A strong advocate for improving the education and preparedness of future engineers, Dr. Fridley recently served in leadership roles on numerous educational committees, including vice-chair of the ASCE Body of Knowledge 2 (BOK2) Committee and chair of the ASCE BOK Educational Fulfillment Committee. Dr. Fridley also served as an educational consultant to the NCEES Engineering Education Task Force from 2007 to 2010, which developed recommendations for changes to the national model law and rules as related to educational requirements for licensure.

Gerald E. Galloway, P.E., Ph.D., Dist.M.ASCE, Hon.D.WRE, NAE

Gerald E. Galloway is a Glenn L. Martin Institute Professor of Engineering, Department of Civil and Environmental Engineering and an Affiliate Professor, School of Public Policy, University of Maryland, College Park, Maryland, where his focus is on disaster resilience and mitigation, sustainable infrastructure development, and water resources and energy policy and management under climate change. A veteran of 38 years of military service, he commanded the Army Corps of Engineers District in Vicksburg, Mississippi, and served for seven years as presidential appointee to the Mississippi River Commission. He has been a member of the faculty of the US Military Academy at West Point, serving successively as Professor of Geography and Computer Science, and Professor and founding Head of the Department of Geography and Environmental Engineering. In 1990 he was appointed by the President as the ninth Dean of the Academic Board (Chief Academic Officer) of the Military Academy. In 1995, he retired from the Army as a Brigadier General and became the Dean of faculty and Academic Programs at the Industrial College of the Armed Forces, National Defense University in Washington, DC

Dr. Galloway has broad experience in dealing with water and infrastructure management issues both within the United States and internationally. He has served as a consultant to the Executive Office of the President, the US Water Resources Council, the World Bank, the Asian Development Bank, the Organization of American States, the UN World Water Assessment Program, federal and state governments and various other organizations. He has been a member of twelve National Academies committees studying complex science issues, three National Academy of Public Administration Panels examining high level national organizational issues and a six year member of the National Academies Water Science and Technology Board. He holds degrees from West Point, Princeton, the Army Command and Staff College, Penn State, and the University of North Carolina, Chapel Hill.

A career long advocate for quality and relevant engineering education, since 1997 Dr. Galloway has been a member of American Society of Civil Engineers committees seeking to modify education requirements to reflect the dynamic challenges of the 21st century and to raise the bar on qualifications for engineering licensing. He served from 2004 to 2012 as Vice-Chair of the ASCE Committee on Academic Prerequisites for Professional Practice (CAP^3)

In 1991, Dr. Galloway was presented the SAME Bliss Medal for contributions to engineering education and, in 1995, the Silver DeFleury Medal by the Army Engineer Association. In 1998, he was given the Association of State Flood Managers' Goddard-White Award. In 2001, ASCE named him the Civil Government Engineer of the year. In 2002, ASCE presented him with the Presidents' Award for service to the country. In 2004 he received the US Geological Survey's John Wesley Powell Award, the Golden Eagle Award from the SAME Academy of Fellows, and the Julian Hinds Award from the Environmental and Water Resources Institute. In 2008 he was presented the Norm Augustine Award by the American Association of Engineering Societies and the OPAL Lifetime Achievement Award by the ASCE. In 2009 he received the Warren Hall Medal, from the Universities Council on Water Resources and in 2011 he received the ASCE President's Award. He is a member of Phi Kappa Phi, national academic honor society, the National Academy of Engineering, and the National Academy of Public Administration.

Kevin D. Hall, Ph.D., P.E., M.ASCE

Kevin D. Hall is a Professor and the Head of the Department of Civil Engineering at the University of Arkansas. He received a BSCE and MSCE from the University of Arkansas, and a PhD from the University of Illinois.

Dr. Hall is a licensed professional engineer in Arkansas. He also serves as the Executive Director of the Mack-Blackwell Rural Transportation Center (MBTC), located at the University. He co-founded MBTC's Center for Training Transportation Professionals (CTTP), which provides training and certification for individuals and laboratories involved in Federal-Aid highway construction.

Dr. Hall served over two years with the U.S. Army Corps of Engineers prior to earning his graduate degrees. He began his academic career in 1993 as an Assistant Professor in the Department of Civil Engineering, focusing his teaching and research on pavement design, materials, construction, and rehabilitation. He is recognized as a leader in both his technical field of pavement engineering and in civil engineering education.

Dr. Hall has advised numerous graduate students and served as principal or co-principal investigator on more than $8 million of publicly and privately funded research. He has published and presented over 200 articles on various aspects of pavement design and materials and served and/or chaired multiple committees, panels, task groups, and other bodies for federal, state, and local agencies.

In the academic community, Dr. Hall served on the ASCE Body of Knowledge Educational Fulfillment Committee (BOKEdFC), and is currently a Senior Director for the Civil Engineering Division of the American Society for Engineering Education (ASEE). He has co-authored 19 articles related to engineering education.

Dr. Hall was inducted into the University of Arkansas Teaching Academy in 2011, and received the Distinguished Faculty Achievement Award for Teaching and Research in 2004.

Forrest M. Holly Jr., Ph.D., P.E.

Forrest M. Holly is Emeritus Professor of Civil and Environmental Engineering at the University of Iowa, and Adjunct Professor of Civil Engineering and Engineering Mechanics at the University of Arizona. His area of specialization is water engineering. He is a licensed professional engineer in seven states.

Dr. Holly received his BS in Civil Engineering from Stanford University; his MS in Civil Engineering (Hydraulics) from the University of Washington; and his Ph.D. in Civil Engineering (Hydraulics) from Colorado State University in 1975. Before entering academe, Dr. Holly worked as an engineer and researcher with the County of San Diego, The U.S. Army Engineers Waterways Experiment Station, Northwest Hydraulic Consultants Ltd, Dames and Moore, and SOGREAH Consulting Engineers in France.

In 1982 Dr. Holly began his academic career at the University of Iowa where he served as Professor, Research Engineer, Department Chair, and Associate Dean of Academic Affairs. He has served as an instructor in the EuroAquae program at the University of Nice, France, and presently teaches as an adjunct faculty member at the University of Arizona.

Dr. Holly served on the Iowa Engineering and Land Surveyors Examining Board for eight years, two of them as Chair. He served four years as President of the International Association of Hydraulic Research, and received its Arthur T. Ippen Award.

He has served on and chaired numerous ASCE and NCEES committees that made key recommendations to improve the standards for licensed professional engineers. Dr. Holly most recently served as vice-chair of the Experiential Fulfillment Committee of ASCE's Committee on Academic Prerequisites for Professional Practice. He has served on numerous national and international professional and technical advisory committees.

Dr. Holly's technical interests include water engineering in natural and built environments, with emphasis on computational simulation of hydrodynamic and transport processes in fluid systems.

Dr. Holly is semi-retired and living in Tucson, Arizona.

Thomas A. Lenox, Ph.D., Dist.M.ASCE

Thomas A. Lenox is an Executive Vice President of the American Society of Civil Engineers (ASCE). He holds a B.S. degree from the United States Military Academy (USMA), M.S. degree in Theoretical & Applied Mechanics from Cornell University, MBA degree in Finance from Long Island University, and a Ph.D. degree in Civil Engineering from Lehigh University.

Dr. Lenox served for over 28 years as a commissioned officer in the U.S Army Field Artillery in a variety of leadership positions in the U.S., Europe, and East Asia. He is a graduate of a number of Army service and specialty schools to include Airborne, Ranger, Jumpmaster, Field Artillery Officer Advanced, the Command & General Staff College, and the Army War College. During his military career, Dr. Lenox spent 15 years on the engineering faculty of USMA – including six years as the Director of the Engineering Mechanics Group and five years as the Director of the Civil Engineering Division. He taught courses in statics, dynamics, mechanics of materials, applied elasticity, structural analysis, advanced structural analysis, steel design, design of structural systems, vibrations engineering, and professional practice. As Director of the Civil Engineering Division at USMA, Dr. Lenox supervised 19 faculty in the ABET-accredited civil engineering program. He served as Chair of both the Civil Engineering Division and the Middle-Atlantic Section of the American Society for Engineering Education (ASEE), and as a member of ASCE's Educational Activities Committee. Dr. Lenox also served as co-principal instructor of the NSF-supported Teaching Teachers to Teach Engineering (T^4E) workshops at West Point in 1996, 1997, and 1998. He was selected as a USMA Professor of Discipline (Civil Engineering) in 1995 and he was the USMA nominee for the 1997 Carnegie Foundation Professor of the Year Award. He retired at the rank of Colonel.

Upon his retirement from the U.S. Army in 1998, Dr. Lenox joined the staff of ASCE. In his position as educational staff leader of ASCE, he led several new educational initiatives – collectively labeled as Project ExCEEd (Excellence in Civil Engineering Education). A notable example is the ExCEEd Teaching Workshop, a nationally recognized workshop that develops inexperienced faculty into effective teachers and role models for the civil engineering profession. He continues to be very active in ASEE and other associations which foster teaching excellence – and has written numerous papers, made presentations, and run workshops dedicated to engineering educational reform. As an ASCE executive, Dr. Lenox led several educational and professional career-development projects for the civil engineering profession with the objective of properly preparing individuals for their futures as civil engineers. An example is his staff leadership of ASCE's initiative to "Raise the Bar" for entry into professional practice.

Dr. Lenox's recent awards include the ASCE's ExCEEd Leadership Award, ASEE's George K. Wadlin Award, ASCE's William H. Wisely American Civil Engineer Award, and the CE News' "2010 Power List – 15 People Advancing the Civil Engineering Profession." In 2013, he was selected as a Distinguished Member of ASCE – the Society's highest membership level.

Dr. Lenox is married to Jane O'Connor Lenox. They have a son, two married daughters, and three grandchildren.

David G. Mongan, P.E., F. ASCE

David G. Mongan retired as the President of Whitney, Bailey, Cox & Magnani, LLC (WBCM), an architectural/engineering/construction firm headquartered in Baltimore, MD on June 30, 2009. WBCM provides professional services in architecture, highway and bridge engineering, design of institutional, commercial and industrial structures, transportation planning, environmental engineering, land development and site engineering, planning and urban design, design of waterfront and marine-related facilities, construction management/inspection, and field surveying.

As President of WBCM, Mr. Mongan's duties included administrative and financial functions, as well as client, contract and business development. He served as Project Manager for an $80 million design-Habuild project extending Baltimore's Light Rail System. He also provided Project Management oversight for WBCM's Traffic Engineering/ITS Division.

Mr. Mongan is active with the American Society of Civil Engineers (ASCE) at the National Level and served as President in 2007-2008. He has been the District 5 Director, Zone 1 Vice President, and Treasurer and served on or as chair of numerous committees. He served as the chair of the ASCE task committee that planned, organized, and implemented the 2006 "Summit on the Future of the Civil Engineering Profession in 2025" and its key report – *The Vision for Civil Engineering in 2025*. This summit and its report articulated an aspirational global vision for the future of civil engineering that provided the foundation for other ASCE initiatives, particularly the second edition of the *Civil Engineering Body of Knowledge for the 21st Century*.

He is Past Chair of the Council on Federal Procurement of Architectural and Engineering Services. He is a past member of the Maryland Chamber of Commerce Board of Directors, past member of the Board of Directors of the Engineering Society of Baltimore, and past Co-Chair of the Legislative Committee the American Council of Engineering Companies/Maryland (ACEC/MD).

Mr. Mongan currently serves on the Maryland State Board for Professional Engineers, is the Immediate Past Chair of the American Association of Engineering Societies and is a member of the Board of Direction and President of Engineers Without Boarders-USA.

He recently received The President's Medal for 2012 from the American Society of Civil Engineers and the Engineering Society of Baltimore's Meritorious Service Award for 2011. In 2003 he was awarded the William H. Wisely American Civil Engineer Award by ASCE. Mr. Mongan holds a Bachelors and Masters of Science in Civil Engineering from the University of Maryland and a Masters in Business Administration from Loyola College of Baltimore, Maryland.

Mr. Mongan and his wife, Janet, live near Baltimore, MD and have two children, Alicia and Matthew.

Craig N. Musselman, P.E., Dist.M.ASCE, F.NSPE, F.ACEC, BCEE

Craig N. Musselman is the president of a Portsmouth, NH-based consulting engineering firm, CMA Engineers, and is a civil and environmental engineer with 38 years experience in the planning, design and construction administration of public works facilities including water supply, wastewater disposal, solid waste management and general civil engineering projects. Through his 27 years of firm management, CMA Engineers has received three national awards and four statewide awards for outstanding and innovative civil engineering projects and for historic preservation. Mr. Musselman holds BSCE and MSCE degrees in civil and environmental engineering from the University of Massachusetts, Amherst.

Mr. Musselman is a former member and chair of the New Hampshire Board of Licensure for Professional Engineers, and has been active on committees and task forces of the National Council of Examiners for Engineering and Surveying (NCEES) for the past fifteen years on matters pertaining to qualifications for licensure and licensure mobility. For the American Society of Civil Engineers (ASCE), he served as the chair of the Licensure Committee of the Committee on Academic Prerequisites for Professional Practice for a period of 10 years. For National Society of Professional Engineers (NSPE), he served as a member of the NSPE Licensure and Qualifications for Practice Committee for 15 years, and as its chair from 2009 through 2013. In that role, he led the effort to prepare the first edition of the Engineering Body of Knowledge report, applicable to engineers of all disciplines. For ABET, Inc., which accredits engineering, technology, applied science and computing programs in the US and globally, he serves as a member of the Board of Directors and the Executive Committee, and is the current Treasurer, responsible for overseeing a $15 million annual budget.

Mr. Musselman is a Distinguished Member of ASCE and a Fellow of both NSPE and the American Council of Engineering Companies (ACEC). He is recognized as a Board Certified Environmental Engineer by the American Academy of Environmental Engineers and Scientists, with a dual certification in both water and wastewater engineering and in solid waste management. He is certified as an engineering expert witness by ACEC. He has been trained in corporate governance by the National Association of Corporate Directors and in financial management by the American Society of Association Executives. He has served for eight years as a local elected official, as a member and chair of a three person board responsible for the governance and day to day management of a New Hampshire municipality with a population of 5,000.

Mr. Musselman received the ASCE President's Medal in 2006 and the NSPE President's Award in 2011, and was New Hampshire's Engineer of the Year in 2004. He is a Fellow of NSPE and ACEC, and a Distinguished Member of ASCE. He writes peer reviewed blog articles on engineering licensure topics for the NSPE website that receive more than 50,000 hits per year. Mr. Musselman is a frequent speaker at national engineering conferences on matters pertaining to engineering education and licensure.

James K. Nelson, Jr., Ph.D., P.E., C.Eng., F.ASCE

James K. Nelson received a Bachelor of Civil Engineering degree from the University of Dayton in 1974. He received M.S. and Ph.D. degrees in civil engineering from the University of Houston. During his graduate study, Dr. Nelson specialized in structural engineering. He is a registered professional engineer in three states, a Chartered Engineer in the United Kingdom, and a fellow of the American Society of Civil Engineers. He is also a member of the American Society for Engineering Education and the SAFE (formerly the Survival & Flight Equipment) Association.

Prior to receiving his Ph.D. in 1983, Dr. Nelson worked as a design engineer in industry and taught as an adjunct professor at the University of Houston and Texas A&M University at Galveston. In industry he was primarily involved in design of floating and fixed structures for the offshore petroleum industry. After receiving his Ph.D., Dr. Nelson joined the civil engineering faculty at Texas A&M University. He joined the civil engineering faculty at Clemson University in 1989 as Program Director and founder of the Clemson University Graduate Engineering Programs at The Citadel and became Chair of Civil Engineering in 1998. While at Clemson he received the Award for Faculty Excellence.

In July 2002, Dr. Nelson joined the faculty at Western Michigan University as Chair of Civil and Construction Engineering. At Western Michigan he started the civil engineering undergraduate and graduate degree programs and also chaired the Departments of Materials Science and Engineering and Industrial Design. In summer 2005 he joined the faculty at The University of Texas at Tyler. At UT Tyler he was the founding chair of the Department of Civil Engineering and instituted the bachelor’s and master’s degree programs. In 2006 he became the Dean of Engineering and Computer Science.

Dr. Nelson's primary technical research interest is the behavior of structural systems. For over 25 years he has been actively involved in the development of analytical tools to evaluate and predict the behavior of free-fall lifeboats. His research has formed the basis for many of the regulations of the International Maritime Organization for free-fall lifeboat performance. Since 1988, he has served as a technical advisor to the United States Delegation to the International Maritime Organization, which is a United Nations Treaty Organization. In that capacity, he is a primary author of the international recommendation for testing free-fall lifeboats and many of the international regulations regarding the launch of free-fall lifeboats. In 1996 he received the United States Marine Safety Award for accomplishments furthering the cause of safety in the marine field.

Dr. Nelson has authored numerous technical papers and co-authored three textbooks. He chaired a national committee of the ASCE for curriculum redesign supporting the civil engineering body of knowledge. Dr. Nelson is actively engaged in developing strategies for enhancing the science, technology, engineering, and mathematics (STEM) education pipeline in Texas and nationally, and has testified before the Texas Senate and House Higher Education Committees on that topic. He chaired the councils for developing articulation compacts for the Texas Higher Education Coordinating Board to develop a statewide articulation compact for several engineering and science programs. He also served on the Texas State Board of Education committee preparing the standards for career and technical education. In addition, Dr. Nelson serves as the chair on the academic advisory committee for the Texas Board of Registration for Professional Engineers, and as chair of the task committee to enhance faculty licensure. He also served as the representative of ASEE on the NCEES Engineering Education Task Force.

Jon D. Nelson, P.E., Dist.M.ASCE, M.NSPE

Jon D. Nelson is a Senior Vice President in the Infrastructure Central Region of the Engineering and Consulting Services Group of Tetra Tech, Inc. in Tulsa, Oklahoma. He has been a consulting engineer for 36 years with most of his experience being in the areas of municipal water and wastewater. After three years with Conoco, Inc. and seven years with small consulting firm in Oklahoma, Mr. Nelson took a position as a project manager with FHC, Inc. of Tulsa, Oklahoma in 1984. He ultimately became chief engineer, vice president and a partner of that firm and held those positions when the firm was acquired by Tetra Tech, Inc. in 2000.

Mr. Nelson holds a BS degree in civil engineering from Kansas State University and an MS degree in environmental engineering from Oklahoma State University. He is licensed to practice engineering in four states and is licensed in Oklahoma as a Class 'A' Waterworks Operator and a Class 'A' Sewage Works Operator.

Mr. Nelson was appointed by the governor of Oklahoma to the State Board of Licensure for Professional Engineers and Land Surveyors in 1995. He served on the board for 12 years and was board chair for two years. He served on the board of directors of the National Council of Examiners for Engineering and Surveying (NCEES) for five years and served as its president in 2004-2005. He chaired the multi-organizational Engineering Licensure Qualifications Task Force for NCEES from 2001 to 2003 and has served on several other NCEES committees. He currently serves on the Civil Exam Development Committee, the Advisory Committee on Council Activities and as the NCEES representative to the American Association of Engineering Societies (AAES). He currently chairs the AAES Licensure Working Group and in 2008 served as chair of AAES.

Mr. Nelson was inducted as a Distinguished Member of the American Society of Civil Engineers (ASCE) in 2009. He currently serves as a member of the ASCE "Raise the Bar" Committee and is chair of the ASCE Technologist Credentialing Task Committee. He has also served as chair of the ASCE Paraprofessional Exploratory Task Committee, as vice chair of the ASCE Paraprofessional Task Committee and as a member of the ASCE Committee on Academic Prerequisites for Professional Practice. Mr. Nelson is an active member of the National Society of Professional Engineers and has served on its Licensure and Qualifications for Practice Committee for the past five years and is currently the NSPE Director at ABET, Inc. Mr. Nelson also served two three-year terms on the Civil Engineering Advisory Council at Kansas State University.

Awards received by Mr. Nelson include a Service Award for serving as President of the Oklahoma Water Environment Association, Distinguished Service Award from the Southern Zone of the NCEES, Distinguished Service Award from the NCEES, and the Kenneth Andrew Roe Award from the American Association of Engineering Societies. He was also honored by the State of Oklahoma by a proclamation designating July 12, 2007 as "Jon D. Nelson, P.E. Engineering and Surveying Licensure Day."

Monte L. Phillips, Ph.D., P.E., F.ASCE, F.NSPE, F.NAFE

Monte L. Phillips is an Emeritus Professor of Civil Engineering at the University of North Dakota. He received a PhD degree from the University of Illinois and BS and MS degrees from the University of North Dakota. During a forty year career as an educator, he served on the faculties of the University of North Dakota, the University of Illinois, and Ohio Northern University, as well as devoting time to private practice as a design consultant and forensic engineer. He is a registered professional engineer in North Dakota.

Dr. Phillips is a Fellow of ASCE, past two-term North Dakota Section president, and has chaired the ASCE Experience Committee and the ASCE BOK Experiential Fulfillment Committee both constituent committees of the ASCE Committee on the Academic Prerequisites for Professional Practice (CAP^3). He has served on the ASCE Committee on Licensure and the Experiential Fulfillment Strategic Planning Subcommittee of the Committee on Licensure and Ethics. He was the recipient of ASCE's William H. Wisely American Civil Engineer Award in 2012.

Dr. Phillips has been an active member of the National Society of Professional Engineers (NSPE) at the local, state, and national levels serving as national president in 1994-95. He is past president of the North Dakota Society of Professional Engineers and was awarded the North Dakota Society's Elwyn F. Chandler Award and the prestigious North Dakota National Leadership Award of Excellence in recognition of outstanding national leadership of the engineering profession. He continues to serve NSPE on the Board of Ethical Review, as a member of the Licensure and Qualifications for Practice Committee, and as chair of the Council of Fellow Executive Committee. He served a five-year term, including chair, of the North Dakota Board of Registration for Professional Engineers and Land Surveyors. He is the recipient of the 2013 NSPE Award, the Society's highest honor.

Dr. Phillips has served on numerous task forces and committees of the National Council of Examiners for Engineering and Survey (NCEES) involved with enhancing the educational requirements for entry into the professional practice of engineering including chair of the Fundamentals of Engineering Effectiveness Task Force, the Licensure Qualifications Oversight Group, and the Faculty Licensure Task Force. NCEES recognized his service with the NCEES Central Zone's Distinguish Service Award (2001), the NCEES Distinguished Service Award (2005), and the NCEES Distinguished Service Award with Special Commendation (2013).

Dr. Phillips represented NCEES on the ABET Board of Directors for seven years and was installed as the ABET President-Elect at the October 2012 BOD meeting. He has been involved with the development of ABET's Strategic Plan for the future as a member of both the Strategic Planning Task Force, the Global Council, as well as their predecessors, the Strategic Planning Committee and the International Activities Council. He has served on the ABET Finance Committee, the Ad-Hoc Outreach Task Group, the Strategic Management Ad-Hoc Task Group on Governance, the Nominating Committee, and he chaired the Admissions Committee. He is scheduled to be installed as the 2013-2014 ABET President in October 2013.

Dr. Phillips is a Fellow and past president of the National Academy of Forensic Engineers; a past six-term member of the Board of Directors of the National Institute of Building Science; has served seventeen years on the National Board of Governors of the Order of the Engineer including two years as chair; and has authored papers and reports on engineering licensure.

Stephen J. Ressler, P.E., Ph.D., Dist.M.ASCE

Stephen J. Ressler is Professor Emeritus at the U.S. Military Academy, West Point, NY. Prior to his retirement in September 2013, he served as Professor and Head of the Department of Civil and Mechanical Engineering at USMA. He holds a B.S. degree from USMA, M.S. and Ph.D. degrees in Civil Engineering from Lehigh University, and a Master of Strategic Studies degree from the U.S. Army War College.

Dr. Ressler served for 34 years as a commissioned officer in the U.S. Army Corps of Engineers and retired at the rank of Brigadier General. He served in a variety of military engineering assignments in the U.S., Europe, and Central Asia, including service as Deputy Commander of the New York District, Corps of Engineers. He is a master parachutist and a registered professional engineer in Virginia. At West Point, he previously served as Director of the ABET-accredited civil engineering program, as Vice Dean for Education, and as USMA Chief of Staff. He taught courses in statics, dynamics, mechanics of materials, structural analysis, advanced structural analysis, steel design, concrete design, construction management, design of structural systems, civil engineering history, and professional practice. As Department Head, he supervised 36 faculty members, two core engineering programs, two ABET-accredited engineering programs, and two research centers.

Dr. Ressler is active in engineering education and a leader in advancing the American Society of Civil Engineers (ASCE) "Raise the Bar" initiative. He currently serves as a member of the ASCE Raise the Bar Committee and the ASCE Committee on Accreditation. He is a past Chair of the ASCE Educational Activities Committee, the ASCE Committee on Curricula and Accreditation, the ASCE Committee on Faculty Development, and the American Society for Engineering Education (ASEE) Civil Engineering Division. He is a member of the ABET Board of Directors and is an ABET program evaluator. For over a decade, he has served as a principal instructor for ASCE's landmark faculty development program—the ExCEEd (Excellence in Civil Engineering Education) Teaching Workshop. He is the developer and director of the West Point Bridge Design Contest, a nationwide Internet-based competition that has introduced engineering to over 50,000 middle school and high school students since 2001. He has written over seventy scholarly papers on engineering accreditation, curriculum assessment, faculty development, teaching techniques, K-12 engineering outreach, and information technology.

In 2007, he deployed to Afghanistan to develop a civil engineering program for the newly created National Military Academy of Afghanistan (NMAA) in Kabul.

Dr. Ressler is a winner of the 2011 ASCE Outstanding Projects and Leaders (OPAL) Award, the ASEE Civil Engineering Division's George K. Wadlin Distinguished Service Award, the ASCE ExCEEd Leadership Award, the ASCE President's Medal, the Society of American Military Engineers Bliss Medal for Outstanding Contributions to Engineering Education, the American Association of Engineering Societies Norman Augustine Award for Outstanding Achievement in Engineering Communications, the ASEE Distinguished Educator Award, the Premier Award for Excellence in Engineering Education Courseware, the ASEE Dow Outstanding New Faculty Award, the EDUCOM Medal for application of information technology in education, and nine ASEE best paper awards. He was recognized as one of the "Top 25 Newsmakers Who Served Construction" in 2000 by the *Engineering News Record* and was named a Distinguished Member of ASCE in 2005.

Jeffrey S. Russell, Ph.D., P.E., Dist.M.ASCE, NAC, F.NSPE

Jeffrey S. Russell is the Vice Provost for Lifelong Learning and Dean of Continuing Studies at the University of Wisconsin-Madison (UW-Madison). In this role, Dr. Russell is responsible for leading the university's programs and services for lifelong learners and nontraditional students. Prior to assuming his current position, Dr. Russell served as Professor and Chair in the Department of Civil and Environmental Engineering (CEE) and was the co-founder of the Construction Engineering and Management (CEM) program at UW-Madison. He received a BS degree in Civil Engineering from the University of Cincinnati and MS and PhD degrees from Purdue University, and is a registered professional engineer in Wisconsin.

Dr. Russell began his academic career in 1989 as an Assistant Professor in the CEE Department and has focused on construction management, innovative project delivery systems, and construction automation and robotics. Over the past 24 years, he has earned a reputation as a leader in education, research, and service to the civil engineering profession through championing diversity, leadership, innovation, and enhanced education for future civil engineers. He has advised over 100 graduate students including 26 PhD students, and served as principal or co-principal investigator for more than $14 million of publicly and privately funded research.

Dr. Russell credits the 1995 American Society of Civil Engineers (ASCE) Civil Engineering Education Conference in Denver, CO and the "Visioning: The Future of Civil Engineering" workshop with his involvement in engineering education. He served as the founding Chair of the ASCE Committee on Academic Prerequisites for Professional Practice (CAP^3) for 10 years.

Dr. Russell is a respected researcher, author, and editor. He has published more than 200 technical papers in the areas of contractor failure, prequalification, surety bonds, constructability, automation, maintainability, warranties, and quality control/quality assurance. In addition, he has authored and published two books, served as editor-in-chief of the ASCE *Journal of Management in Engineering* (1995-2000), and served as the founding editor-in-chief of the ASCE publication *Leadership and Management in Engineering* (2000-2003).

Dr. Russell's awards include the National Science Foundation Presidential Young Investigator (1990), ASCE Collingwood Prize (1991), ASCE Edmund Friedman Young Engineering Award (1993), ASCE Walter L. Huber Civil Engineering Research Prize (1996), ASCE Thomas Fitch Rowland Prize (1996), Outstanding Researcher of the Construction Industry Institute (2000), ASCE President's Medal (2003), NSF Presidential Award for Excellence in Science, Mathematics, and Engineering Mentoring (2004), Engineering News Record Newsmaker (1996 and 2005), ASCE William H. Wisely Civil Engineer Award (2005), National Society of Professional Engineers Engineering Education Excellence Award (2005), Wisconsin Society of Professional Engineers Engineering Educator Award (2007), ASCE Excellence in Civil Engineering Education (ExCEEd) Leadership Award (2007), Distinguished Membership of ASCE (2009), Wisconsin Distinguished Service Award ASCE WI section (2009), ASEE George Wadlin Service Award (2010), the Peurifoy Research Award (2010), and Mentor of the Year Award from the National Society of Professional Engineers. He served on the ASCE Board of Direction (1997-2000), was elected to the National Academy of Construction (2011), and was elected as Fellow of the National Society of Professional Engineers (2011).

Stuart G. Walesh, Ph.D., P.E., Dist.M.ASCE, D.WRE, F.NSPE

Stuart G. Walesh is an independent consultant providing management, engineering, and education/training services to private, public, academic, and volunteer sector organizations. Prior to starting his consulting business, Dr. Walesh served as Dean and Professor in the College of Engineering at Valparaiso University and before that he held various positions within Donohue & Associates, headquartered in Wisconsin, while leading creation of a water resources service line. Earlier he was a project engineer and project manager at the Southeastern Wisconsin Regional Planning Commission where he led the development of in-house watershed planning capability. He received his BS degree in Civil Engineering from Valparaiso University, MS degree from Johns Hopkins University, PhD from the University of Wisconsin-Madison, and is a professional registered engineer in Indiana and Wisconsin.

Dr. Walesh was motivated to join what is now ASCE's Raise the Bar campaign in October 1998 while attending the ASCE convention in Boston. He entered the back of the convention hall just in time to hear the final address of Lou Graef, the outgoing ASCE president. Lou articulated a passionate vision of the need to reform the civil engineering education and, within a few months, Walesh was a member of what became the ASCE Committee on Academic Prerequisites for Professional Practice (CAP^3) for 10 years. While serving on CAP^3, Dr. Walesh chaired the first Body of Knowledge Committee and edited the report, edited the second edition, assisted the American Academy of Environmental Engineers in preparing their BOK, and provided BOK advice to two ASCE certification boards. In 2011, he began working on NSPE's Engineering BOK project.

Water resources engineering is Dr. Walesh's technical specialty. He led or participated in watershed planning, computer modeling, flood control, stormwater and floodplain management, groundwater, dam, and lake projects. His experience includes project management, research and development, stakeholder participation, and consulting and expert services in litigation.

He authored six books the most recent of which is *Engineering Your Future: The Professional Practice of Engineering*. He is author or co-author of hundreds of publications and presentations in the areas of engineering, education, and management and has facilitated or presented hundreds of workshops, seminars, webinars, and meetings throughout the U.S. He has spoken at engineering education and practice conferences in eight countries outside of the U.S., two times as the invited keynote speaker. Dr. Walesh chaired national technical committees and served on the Indiana licensing board.

Dr. Walesh's awards include the Consulting Engineers of Indiana Public Service Award (1995), Distinguished Service Citation from the College of Engineering at the University of Wisconsin (1998), ASCE Excellence in Civil Engineering Education (ExCEEd) Leadership Award (2003), Distinguished Member of ASCE (2004), Diplomate of the American Academy of Water Resources Engineers (2005), Indiana Society of Professional Engineers Engineer of the Year (2007), NSPE Distinguished Service Award (2007), ASCE William H. Wisely American Civil Engineer Award (2008), ASCE George Wadlin Service Award (2009), Fellow of the National Society of Professional Engineers (2010), and Valparaiso University Distinguished Alumni Achievement Award (2013).

This page intentionally left blank

Index

Page numbers followed by *e*, *f*, and *t* indicate equations, figures, and tables, respectively.