AC 2012-4573: THE RAISE THE BAR INITIATIVE: RESPONSE OF THREE CURRICULA TO ASCE'S EDUCATIONAL RECOMMENDATIONS

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Kevin D. Hall is a professor and the Head of the Department of Civil Engineering at the University of Arkansas, and holds the 21st Century Leadership Chair in civil engineering. He received his B.S.C.E from the University of Arkansas in 1986. After working for just over two years with the U.S. Army Corps of Engineers in Tulsa, Oklahoma, he returned to the University of Arkansas and completed his M.S.C.E. in 1990. He earned his Ph.D. from the University of Illinois in 1993 prior to joining the faculty of the University of Arkansas. Hall is very active in both the research and education communities. He has published more than 70 articles and given more than 150 presentations to various groups. His primary teaching and research interests include pavement design, materials, construction, and rehabilitation, in addition to the topics of professionalism, licensure, and ethics. On the education front, he serves as the co-Chair of the ASCE Body of Knowledge Education Fulfillment Committee (BOKEdFC), and is an active participant in the Civil Engineering Division of ASEE. In terms of technical/research efforts, he currently serves on eight committees, task groups, and panels through the Transportation Research Board (chairing one standing committee of TRB and one NCHRP Project Panel), and numerous committees with ASTM and industry. Hall founded the Center for Training Transportation Professionals at the University of Arkansas, which provides training and certification for QA/QC testing technicians in Arkansas. He has been recognized as the top teacher in his department one time, and the top researcher a total of five times; he also received the University of Arkansas' highest faculty recognition the Arkansas Alumni Association Outstanding Faculty Award for teaching and research. Hall is a registered Professional Engineer in the state of Arkansas.

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James K. Nelson received a bachelor's of civil engineering degree from the University of Dayton in 1974. He received the master's of science and doctorate of philosophy degrees in civil engineering from the University of Houston. During his graduate study, Nelson specialized in structural engineering. He is a registered Professional Engineer in four 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 Association. Prior to receiving his Ph.D. in 1983, 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., 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. In July 2002, 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, 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. Nelson's primary technical research interest is the behavior of structural systems. For almost 25 years, he has been actively involved in evaluating the behavior of free-fall lifeboats and the development of analytical tools to predict that behavior. His research has formed the basis for many of the regulations of the International Maritime Organization for free-fall lifeboat performance. Since 1998, Nelson 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. He has authored many technical papers that have been presented in national and international forums and co-authored three textbooks. Nelson chaired a national committee of the American Society of Civil Engineers for curriculum redesign supporting the civil engineering body of knowledge. He is actively engaged in developing strategies for enhancing the STEM education pipeline in Texas and nationally and has testified before the Texas Senate Higher Education Committee in that regard. He served on a committee of the Texas Higher Education Coordinating Board to develop a statewide articulation compact for mechanical engineering and currently chairs the council for developing articulation compacts in other engineering disciplines. He also served on the Texas State Board of Education committee preparing the standards for career and technical education.

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.

<u>The University of Arkansas</u>

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.

The University of Texas at Tyler

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

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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)		Course		Second Semester (Spring)		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)		Course		Second Semester (Spring)		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)		Course		Second Semester (Spring)		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)		Course		Second Semester (Spring)		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
ENGL 1013	Composition I	3
MATH 2554	Calculus I	4
CHEM 1113	University Chemistry 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 2574	Calculus III	4
MEEG 2003	Statics	3
GNEG 1122	Introduction to CAD	2
	Fine Arts Elective	3
CVEG 2053	Surveying Systems	3
CVEG 2051L	Surveying systems Laboratory	1
	Semester Credit Hours	**16**

Second Semester (Spring)

Course		Hrs
CVEG 2113	Structural Materials	3
INEG 3133	Engineering Statistics	3
MATH 3404	Differential Equations	4
GEOL 3002	Geology for Engineers	2
	Humanities/Social Science	3
MEEG 3013	Mechanics of Materials	3
	Semester Credit Hours	**18**

Junior Year

First Semester (Fall)

Course		Hrs
CVEG 3304	Structural Analysis	4
CVEG 3133	Soil Mechanics	3
	Science Elective	4
CVEG 3213	Hydraulics	3
CVEG 3413	Transportation Engineering	3
	Semester Credit Hours	**17**

Second Semester (Spring)

Course		Hrs
CVEG 3022	Public Works Economics	2
CVEG 3223	Hydrology	3
CVEG 3243	Environmental Engineering	3
CVEG 4313	Structural Steel Design	3
	Social Science Elective	3
	Engineering elective	3
	Semester Credit Hours	**17**

Senior Year

First Semester (Fall)

Course		Hrs
CVEG 4143	Foundation Engineering	3
CVEG 4433	Transportation Pvmts and Materials	3
CVEG 4852	Professional Practice Issues	2
CVEG 4303	Reinforced Concrete Design I	3
	Social Science Elective	3
CVEG ( )	Civil Engineering Design Elective	1
	Engineering Design Elective	3
	Semester Credit Hours	**18**

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	1
	Social Science Elective	3
	Semester Credit Hours	**16**

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