Review of the Literature on Engineering Society Involvement in Undergraduate Engineering Education

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Overview

Introduction to the Relevant Research

This paper was prepared by the staff of the National Academy of Engineering as part of a National Science Foundation–sponsored project on the Engagement of Engineering Societies in Undergraduate Engineering Education. The views expressed in these pages are those of the authors of this paper and the authors of the cited works, and are intended to help inform and stimulate discussion. The document is not a report of the National Academy of Engineering and has not been subjected to its review procedures.

This summary is based on a search for articles in databases maintained by the American Society for Engineering Education (ASEE), Institute of Electrical and Electronics Engineers (IEEE), Education

Resources Information Center (ERIC), ProQuest Research Library, Scopus, Web of Science, and Google Scholar as well as individual public engineering society websites. Databases were queried for articles that combined the terms "engineering education" and "professional societies" and articles on engineering education that also mentioned an engineering society (e.g., "engineering education" and IEEE"). The search identified 61 relevant papers published between 1991 and 2015. The bibliographic entries in the following pages present each article's citation with an abstract or short description.

Although many of the engineering societies engage in activities related to undergraduate education, the literature is limited and documentation of the work is often informal. Much of the literature is from non-peer-reviewed sources and is descriptive or qualitative in nature. Some reports discuss individual classroom outcomes (Bielefeldt 2010; Chowdhury et al. 2007; Koehn et al. 2006), but extremely few include data on larger impacts. (See Section 2[1] for literature related to evaluation.)

One of the most documented examples of the role of engineering societies in undergraduate education is the American Society of Civil Engineers' (ASCE) Body of Knowledge project (BOK; ASCE 2008). The BOK describes the knowledge, skills, and attitudes that, according to ASCE, all civil engineers should possess, presented in the form of 4 foundational, 11 technical, and 9 professional outcomes. The BOK has influenced course design in existing subdisciplines, such as construction engineering (Varma 2005), and guided the introduction of new topics, such as sustainability (Jha and Lynch 2007; Theis et al. 2008). Some research has assessed the influence of the BOK on faculty development efforts (Doran et al. 2010; Estes and Welch 2006; Hains et al. 2007).

A number of other engineering societies have developed guidance similar to ASCE's BOK. The IEEE Computer Society created the *Software Engineering Body of Knowledge.*[2] The International Council on Systems Engineering, Institute of Electrical and Electronics Engineers, and Systems Engineering Research Center published the *Guide to the Systems Engineering Body of Knowledge*.[3] The American Society of Mechanical Engineers (ASME) features a *Guide to the Engineering Management Body of Knowledge (BOK)*.[4] The National Society of Professional Engineers has the *Professional Engineering Body of Knowledge*.[5] The American Academy of Environmental Engineers and Scientists created the *Environmental Engineering Body of Knowledge*[6], and the Society for Manufacturing Engineers has defined a body of knowledge for certified manufacturing engineering programs.[7] These are just a few examples of engineering bodies of knowledge.

The engineering societies also play a role in setting the discipline-specific criteria used by ABET to accredit engineering education programs around the nation. ASCE, for example, is responsible for establishing the criteria for both civil engineering and architectural engineering programs, and has done so by blending elements of its BOK with the outcomes-based ABET Engineering Criteria 2000 (Estes 2011). Society members also volunteer as program evaluators. In these ways the societies can influence undergraduate education. (See Section 1.1 for literature related to bodies of knowledge and other standards set by engineering societies.)

[1] Text in blue links to the appropriate section in the bibliography.
[2] www.computer.org/web/swebok/index
[3] http://sebokwiki.org/w/downloads/SEBoKv1.3_full.pdf
[4] https://www.asme.org/products/books/guide-management-body-of-knowledge
[5] https://www.nspe.org/sites/default/files/resources/nspe-body-of-knowledge.pdf
[6] http://www.aaees.org/publications-eebodyofknowledge.php
[7] http://www.sme.org/cmfge/

Another way engineering societies influence undergraduate engineering education is through local student chapters (Section 1.4). Student chapters of discipline-specific and affinity societies (i.e., those aimed at supporting populations traditionally underrepresented in engineering) exist at most engineering schools and often provide opportunities for students to develop leadership capability.

Among other potential benefits, they can be a source of peer support, which can increase student self-confidence and persistence, especially for students who belong to affinity-based engineering society chapters such as the National Association of Black Engineers (Du Maine et al. 2003) and the Society for Women Engineers (SWE). Researchers at the Colorado School of Mines, for example, cite student participation in the local SWE chapter as a factor in both the school's high percentage of female engineering enrollments (compared to the national average) and higher percentage of female than male students who graduate with four-year degrees (Lasich and Sulzbach 2008). However, the effectiveness of student chapters can be hindered by the management styles of faculty advisors (Burtner and Rogge 2003).

In addition, student chapters are often the locus for capstone design challenges, such as ASCE's concrete canoe and steel bridge competitions, the Society for Automotive Engineers' Collegiate Design Series, and ASME's human-powered vehicle competition. Team-based design competitions can improve student motivation to learn, support diversity (Davids et al. 2007), increase understanding of the design process (Stover 2007), and build deeper content knowledge. But such competitions are not without possible negative consequences, such as the risk of being a distraction from classes (Schuster et al. 2006). (See Section 1.2 for literature related to society competitions and conferences.)

Lack of diversity in engineering education, among both faculty and students, is well recognized. Engineering societies can provide leadership and an organizational structure to promote academic performance and retention of underrepresented populations in engineering. For example, working with Intel, SWE and the Coalition of Engineering Minority Societies created a cash reward program to recognize students from underrepresented groups who substantially raised their grade point averages (Newell et al. 2004). Societies can also support the development of faculty professional networks, which can reduce isolationism and decisions to leave engineering, especially for women faculty (Schulz et al. 2002).

The focus of this project is undergraduate education, which is part of a larger education-workforce continuum. Societies' involvement in undergraduate engineering includes informal (i.e., nonclassroom) educational activities such as service learning and community service projects (Eschenbach and Cashman 2004), outreach to K–12 schools (Bogue et al. 2013), and support of working engineers through continuing education initiatives (Estey 2005). (See Section 1.3 for literature related to outreach, service learning, and professional development.)

The following bibliography presents articles about engineering society engagement in and contributions to both formal and informal education, including field-specific standards and criteria, student chapters, outreach, and national competitions. The literature is broadly categorized by engineering society educational involvement, evaluation and assessment of educational outcomes, and general engineering education reports relevant to the societies (Section 3). The first section is further grouped based on the format of engineering society influence or involvement in engineering education.

This review reveals gaps in the rather limited existing literature and helps paint a more accurate picture of the extent and nature of engineering societies' contributions to improving the quality and effectiveness of US undergraduate engineering education.

Relevant Research

1. Examples of Engineering Society Involvement in and Influence on Engineering Education (categorized by format of involvement/influence)

1.1. Standards, Recommendations, and the Influence of Standards on Specific Curricula

ASCE [American Society of Civil Engineers]. 2008. Civil Engineering Body of Knowledge for the 21st Century: Preparing the Civil Engineer for the Future. Body of Knowledge Committee. Reston, VA.

> Staff description[8]: This 2008 version of the Body of Knowledge (BOK) report outlines 24 outcomes in the categories of foundational, technical, and professional skills and knowledge. It is an update and expansion of the first BOK report, published in 2004. The purpose of the report is to set forth the requirements and outcomes that should guide the education and practice of civil engineers.

ASEE [American Society for Engineering Education]. 2014. Transforming Undergraduate Education in Engineering, Phase I: Synthesizing and Integrating Industry Perspectives. Washington.

> Abstract: ASEE's "Transforming Undergraduate Education in Engineering: Mobilizing the Community for Change" project seeks to identify the critical components of engineering curricula, pedagogy, and educational culture necessary to support the education of engineers over the next decades of the 21st century. Technology has radically changed the world we live in and engineers, scientists, mathematicians, and technologists have been central to these developments. Technology has also transformed the typical engineering workplace and practice. Practicing engineers working today have little need for many of the facts and methodologies that were essential just a decade ago and now require skills and knowledge not previously anticipated. Engineering education has not kept pace with changes caused by technology. Content, pedagogy, and university culture have remained relatively static, and although there have been some changes, the most common engineering classroom is still a passive lecture. The project intends to catalyze change by building broad and thorough consensus within the engineering community on a shared vision of the future of engineering education. The project will enumerate critical steps for the vision to be achieved and will coordinate the pursuit of each critical step throughout the engineering education community. In Phase I of the project, "Synthesizing and Integrating Industry Perspectives," ASEE brought together industry and academic representatives for an intensive exploration of the knowledge, skills, and abilities needed in engineering today and in the coming years by the primary customer of

[8] In the absence of a copyrighted abstract, a brief description of the resource has been prepared by the NAE project staff.

engineering education, namely employers. This group found the engineering profession and the abilities of engineering graduates under pressure from several directions, with current training viewed as pursing a trajectory that may lag behind the technological demands of the nation in 2024. Areas of growing importance include: project management, effective product development, system integration, leadership, communication, and the ability to merge engineering, business, and societal priorities. This is the workshop report for Phase I. © American Society for Engineering Education, 2014.

Arumala, J.O. 2011. “Education and training in civil engineering: Beyond the classroom.” Leadership and Management in Engineering 11(2):80-87.

Staff description: This paper presents ASCE’s Vision 2025 as a strategy that complements ASCE’s Body of Knowledge report. Vision 2025 calls for training that provides “real-life experiences” outside of the classroom. Such training would include “routine incorporation of risk assessment and management into projects, ethical handling of contracts and procurement, and involvement in public policy” and would involve service learning activities, basic research projects, and outreach programs.

Doran, M., et al. 2010. “Strengthening the body of knowledge: How integration of practicing engineers as adjunct faculty can enhance educational outcomes.” 2010 ASEE Annual Conference and Exposition. American Society for Engineering Education.

Abstract: Reformation of engineering education has been discussed for many decades in the United States. Noteworthy are the periodic reports, beginning with the Mann Report of 1918, that have emphasized the need for engineering education reform. Since Mann’s report there have been many other significant reports published from 1930 to present that stress this need. Two such studies were those completed in recent years by the American Society of Civil Engineers (ASCE)[1] and the US National Academy of Engineering (NAE)[2]. The impetus for both was a realization that major changes in engineering education were needed to meet 21st century challenges. Important conclusions from these studies are that civil engineering education must foster more interdisciplinary collaboration, include more team-based learning, and provide more learning experiences that feature problem solving involving socio-economic challenges as well as the application of engineering skill. Such collaboration, knowledge, experience, and engineering skill are required of effective practitioners. The purpose of this paper is to describe why the University of Wisconsin-Madison Department of Civil & Environmental Engineering (CEE) has worked to integrate practitioners from multiple disciplines who possess extensive professional practice experience within the faculty team as Adjunct Faculty, how we are doing this, and the unique aspects the Adjunct Faculty are contributing to the educational process. The paper will specifically address how this engagement of Adjunct Professors as collaborative members of the team help the department to achieve the four characteristics of a model faculty described by the ASCE publication, Body of Knowledge for the 21st Century (BOK2) Committee[3] as: 1) Scholars, 2) Effective Teachers, 3) Having Relevant Practical Experience, and, 4) Providing Positive Role Models. The paper will also describe the deliberative process we have used to develop a formal charter to guide and describe this effort, and the care taken in Adjunct Faculty appointments to adhere to the recommendation of the BOK2 Committee[4] that “...practitioner participants should meet the same criteria as the full-time faculty as described in this section - namely, scholarship, teaching effectiveness, and positive role modeling.” © American Society for Engineering Education, 2010.

Estes, A., and R. Welch. 2006. “The civil engineering faculty of the future.” 113th Annual ASEE Conference and Exposition, 2006. American Society for Engineering Education.

> Abstract: The American Society of Civil Engineers (ASCE) has published the Civil Engineering Body of Knowledge (BOK) for the 21st Century that attempts to define the knowledge, skills and attitudes required of a civil engineer. A section of that document addresses who should teach this body of knowledge. It concludes that civil engineering faculty must be scholars, effective teachers, practitioners, and role models. While true, there are a number of complex issues that arise such as whether it is possible for one person to possess all of these attributes, whether such a model best serves the projected trends in civil engineering education, and whether these needs are applicable to and can be enforced for non-traditional, non-university civil engineering programs. As a new committee (BOK-2) has formed to write the second edition of this document, the ASCE Committee on Faculty Development is revising the “who should teach” chapter for this effort. This paper discusses some key issues that are relevant to the civil engineering faculty of the future. © American Society for Engineering Education, 2006.

Estes, A.C. 2011. “How the new architectural engineering program criteria differs from the new Civil Engineering Program criteria.” 118th ASEE Annual Conference and Exposition, 2011. American Society for Engineering Education.

> Abstract: There are 17 ABET accredited architectural engineering (AE) programs in the country and over 200 civil engineering (CE) programs. To gain accreditation, a program must meet the ABET general criteria common to every engineering program and specific criteria that are unique to an individual program. The American Society of Civil Engineers is the lead professional society in this effort for both CE and AE programs. Recently the Civil Engineers rewrote and implemented the Civil Engineering ABET Program Criteria to incorporate changes in the ABET general criteria, the publication of the Civil Engineering Body of Knowledge I, and the work accomplished on ASCE Policy 465. This year, a subcommittee of the Architectural Engineering Institute Academic Council rewrote the ABET Program Criteria for Architectural Engineering (AE) Programs. In the process, the writers consulted many of the same documents used by the civil engineers and faced many of the same issues. On some of these issues, the AE community chose to follow the same path as the civil engineers and on other issues chose an alternative path. This paper examines the new AE Program criteria and reports on the issues and decisions that were made to create it. Comparisons are made with the existing program criteria and the new civil engineering program criteria. The issues include the recognized sub-disciplines of architectural engineering, the minimum degree of attainment in each sub-discipline, the role of architecture, the role of design, the need for flexibility to preserve the uniqueness of the various programs, and the minimum requirements for math, science and engineering fundamentals. The CE Division will hopefully benefit from seeing the similar challenges in developing program criteria faced by a totally different group and the decisions they reached. © 2011 American Society for Engineering Education.

Evans, J., et al. 2007. “The role of humanities and social sciences in the civil engineering body of knowledge.” 114th Annual ASEE Conference and Exposition, 2007. American Society for Engineering Education.

> Abstract: The American Society of Civil Engineers has identified a Body of Knowledge (BOK) and is in the process of developing a second version. The first BOK identified the requirement for a broad education, and the second BOK will provide further structure to this aspect of civil engineering education. This paper explores the role of humanities and social sciences in the education of a 21st

century engineer. Humanities and social sciences along with mathematics and natural science are at the core of liberal learning. The humanities include subjects such as art, history and literature while social science includes subjects such as economics, political science, sociology and psychology. Traditional engineering education emphasizes mathematics and sciences, but the role of humanities and social sciences is not well understood and appreciated by many students and faculty. Humanities and social sciences are a valuable part of a balanced educational experience because they contribute to understanding the context of problems and development of skills in critical thinking. Civil engineers need to consider the context of problems as they design solutions, and so the quality of solutions depend in part on the richness of the engineer's understanding of context. A civil engineer's thinking must be systematic and guided by analysis and assessment of relevant information. A critical thinker 1) raises vital questions and problems, formulating them clearly and precisely; 2) gathers and assesses relevant information, using abstract ideas to interpret it effectively, comes to well-reasoned conclusions and solutions, testing them against relevant criteria and standards; 3) thinks open-mindedly within alternative systems of thought, recognizing and assessing, as need be, their assumptions, implications, and practical consequences; and 4) communicates effectively with others in figuring out solutions to complex problems. For the civil engineering student educated predominantly in areas of math, science and engineering, the vital questions become math, science and engineering questions. The relevant information to be gathered becomes limited to math, science and engineering data, and the engineer may not think open-mindedly about the alternatives. The engineer might encounter difficulty communicating the questions and answers to a broader audience. Alternatively, an engineer whose education includes substantial grounding in humanities and social sciences is likely to recognize the impact of the engineering decisions not only upon the more narrowly framed math, science and engineering questions but upon the more broadly framed questions informed by social sciences and the humanities. In summary, a broad education is 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.

Farison, J. 2010. "ASEE's role in accreditation review of ABET EAC programs in engineering, engineering phys., and engineering sci. (et al.): A brief history, the current status, and a look ahead." 2010 ASEE Annual Conference and Exposition. American Society for Engineering Education.

Abstract: While not as numerous as civil engineering, electrical engineering, mechanical engineering, and other "common" engineering baccalaureate programs, there is a surprising number of engineering programs with a "more general" program title., and, while some might assume that these "more general" programs would largely be offered only by smaller, primarily private institutions, there are a considerable number of major state (and private) institutions that also offer these programs. This paper presents a brief history and a more detailed look at the current status of the set of programs that the Accreditation Board for Engineering and Technology (ABET) now lists under the program heading of "Engineering, Engineering Physics, and Engineering Science" plus a few additional programs with similar names or with other variations outside of ABET's standard set of program titles that ABET has assigned to ASEE. This set of programs has been assigned to ASEE for purposes of providing program evaluators (PEVs) for accreditation visits. Further, this paper provides a look ahead at the prospective accreditation review load for ASEE PEVs. This information is important in helping to estimate the number of ASEE PEV assignments that will be needed over the next several years. Perhaps surprisingly, that number is not easily estimated ahead, as only the years for the next scheduled general review (NGR) of programs already accredited can be determined from the ABET public website. Several other variables that lead to the final number can only be estimated. Nonetheless, a "forecast" is important for the planning of ASEE's PEV workload and therefore the anticipated number of ASEE PEVs needed each year. Further, the roster of multidisciplinary engineering programs itself is an important source of information about this set of engineering degree programs and the institutions that provide them. © American Society for Engineering Education, 2010.

Hains, D., et al. 2007. "Teaching the BOK? Challenges for faculty and programs." 114th Annual ASEE Conference and Exposition, 2007. American Society for Engineering Education.

Abstract: In February 2007, the Second Edition of Civil Engineering Body of Knowledge (BOK) for the 21st Century was released for review by the American Society of Civil Engineers. The revised BOK uses an outcome-based approach and Bloom's Taxonomy of Educational Objectives to define what should be taught to and learned by tomorrow's civil engineers. The 26 outcomes 16 technical and ten professional, collectively prescribe the necessary depth and breadth of knowledge, skills, and attitudes required of an individual aspiring to enter the practice of civil engineering at the professional level in the 21st century. Central to achieving the BOK is the university-level education and those who teach the BOK are critical to this education. The ten professional outcomes which include leadership, teamwork, communication, history and heritage, professional and ethical responsibility, and life-long learning, can present challenges to some programs since they fall outside the traditional teaching roles of faculty. Colleges and universities will need to adjust their programs to educate and train faculty to teach the BOK. The authors draw on their experience serving on ASCE's Second Edition of the Body of Knowledge Committee, ASCE's Committee on Academic Prerequisites for Professional Practice Committee, and as the Director of the Center for Teaching Excellence at the United States Military Academy. This paper discusses the non-traditional faculty model in the Department of Civil & Mechanical Engineering at the United States Military Academy and how we've modified our program and educated our faculty to teach the BOK. Many of these modifications including faculty education and training programs can easily be adapted to colleges and universities across the country. © American Society for Engineering Education, 2007.

Houghtalen, R.J., and G.M. Rogers. 2004. "Don't give up good 'Teaching Principles' to teach ethics." ASEE 2004 Annual Conference and Exposition. American Society for Engineering Education.

Abstract: Teaching engineering students professional ethics is a challenge. Most of our students think ethics is common sense and does not need to be taught. Furthermore, the topic is not easy to make interesting. However, principles of good teaching can be applied to any topic, including this one. This paper explores two ways to teach professional ethics; one way is through a mock public meeting, the other is through personal testimony. Both have proven to be interesting to students and effective in revealing the subtleties of compromising situations that arise in engineering practice. The dual goals of exposing students to the ASCE Code of Ethics and applying the Code to an ethical situation are being accomplished based upon assessment results from the RosE-portfolio, the system set up for documenting student learning outcomes. The two methods we have used to inject enthusiasm and relevance into the topic of professional ethics are proven teaching techniques. One method is the mock public meeting. A student team, working on one of our senior design projects, is instructed to hold a public meeting. Their role is to present their project, which is somewhat controversial, on behalf of their client. Other students are given roles in the meeting such as city or county engineers, state agency representatives, property owners, clients, and representatives of the public, some of which are rather surly. Invariably, the student engineers step over an ethical line

when fielding difficult questions. Unbeknownst to the class, this leads into a discussion on the subtleties of professional ethics. The second method involves the personal testimony of a practicing engineer who has faced a career threatening ethical situation. Students love stories, and a true story told by a practicing engineer that involves the vagaries of ethics grabs their attention. It also causes students to reflect on the Code of Ethics in more depth than they generally think is necessary. © American Society for Engineering Education, 2004.

Jha, M.K., and D.R. Lynch. 2007. "Role of globalization and sustainable engineering practice in the future civil engineering education." WIT Transactions on Ecology and the Environment 102:641-650. 3rd International Conference on Sustainable Development and Planning, SDP07; Algarve, Portugal, April 25–27, 2007.

Staff description: This paper looks at the efforts of the American Society of Civil Engineers to address the issues of globalization and sustainability with specific reference to the ASCE Body of Knowledge.

Kirkpatrick, A.T., et al. 2012. "ASME Vision 2030's recommendations for mechanical engineering education." 2012 ASEE Annual Conference and Exposition. American Society for Engineering Education.

Abstract: The role and scope of the engineering practice is transforming rapidly and academia should change to better prepare graduates. The ASME Vision 2030 Task Force investigated the current state of mechanical engineering education and practice within industry through assessment of recent literature addressing the shape and content of engineering and engineering technology education, through conducting workshops among stakeholders at key conferences and gatherings, and by extensive surveys of industry supervisors and early career engineers. As a result, the Task Force has formally recommended, and begun to advocate for, specific actions to strengthen the following seven aspects of undergraduate mechanical engineering education curricula: creating curricula that inspire innovation and creativity, increasing curricular flexibility, offering more authentic practice-based engineering experiences, developing students' professional skills to a higher standard, attracting a more diverse student body, increased faculty expertise in professional practice, and adapting post-graduate education to support specialization for practicing engineers. Partnership between industry, professional societies, government, and academia is needed to successfully implement these recommendations and help develop the full potential of mechanical engineering graduates. Initial actions have been taken towards implementing several of these recommendations. © American Society for Engineering Education, 2012.

Maccariella, J. 2007. "The role of adjuncts in teaching ASCE's body of knowledge." 114th Annual ASEE Conference and Exposition, 2007. American Society for Engineering Education.

Abstract: The National Research Council (NRC) published a report citing "serious concerns" with engineering graduates. This view is shared by the American Society of Civil Engineers' (ASCE) Body of Knowledge (BOK) which has outlined several desired learning outcomes. To address these concerns, a two-semester senior design course was developed and taught by an adjunct faculty member at Rowan University. Student evaluations over the past several years consistently result in high scores when this course is taught by the adjunct. Therefore, it is believed that adjunct instructors' practical experience and knowledge of day-to-day operations of engineering projects effectively supplements the traditional engineering curricula. It is further believed that the aforementioned "serious concerns" with engineering graduates are being addressed, while effectively integrating ASCE's BOK. © American Society for Engineering Education, 2007.

Theis, R., et al. 2008. “Pathways to learning: Orchestrating the role of sustainability in engineering education.” 2008 ASEE Annual Conference and Exposition. American Society for Engineering Education.

Abstract: The 2001 Action Plan put forth by the American Society of Civil Engineers (ASCE) articulates the “principles of sustainable development” 1 as primary to the ASCE’s code of ethics to be implemented in engineering education. Previously, in June of 1999, the Board of Directors for the American Society for Engineering Education (ASEE) approved the following statement on sustainable development in education: Engineering students should learn about sustainable development and sustainability in the general education component of the curriculum as they are preparing for the major design experience.... Engineering faculty should use system approaches, including interdisciplinary teams, to teach pollution prevention techniques, life cycle analysis, industry ecology, and other sustainable engineering concepts. 2 ASEE has aligned this statement with the program outcomes for ABET Criteria 3 which include the following 3: 3c) An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability and sustainability; 3f) An understanding of professional and ethical responsibility; and 3h) The broad education necessary to understand the impact of engineering solutions in a global and societal context. Thus, integrating the theory and practice of sustainability into a curriculum is a critical issue for engineering educators to address. We seek to examine how best to insert these criteria of sustainability into our unique university context so as to better meet the educational objectives mandated by ABET. We are an undergraduate technical university in the American Southwest offering degrees in aeronautical sciences, global security and intelligence, space physics, and aerospace, mechanical, electrical, and computer engineering. If our educators are to initiate sustainability into these programs, we must first examine pathways to learning and how best to introduce sustainability to the campus and curriculum. Pathways to learning include not only transmission of information in set course curriculum but also speaker forums, inter-school partnerships, textbooks, study abroad, capstone design programs, internships, field trips and other opportunities that create real-world learning. Such pathways are also generated through collaborative partnerships between faculty and library staff. © American Society for Engineering Education, 2008.

Turner, A.K. 2010. “Defining competencies for geo-engineering: Implications for education and training.” 11th Congress of the International Association for Engineering Geology and the Environment, IAEG 2010.

Staff description: This paper looks at how the American Society of Civil Engineers’ competency model can be applied to the field of geo-engineering. The paper goes on to discuss the implications of this model for education and training.

Varma, V.K. 2005. “Basic elements of the 21st century body of knowledge for a construction professional: Challenges for construction educators.” 2005 ASEE Annual Conference and Exposition. American Society for Engineering Education.

Abstract: The American Society of Civil Engineers has recently released a report, “Civil Engineering Body of Knowledge for the 21st Century: Preparing the Civil Engineer for the Future.” It calls for sweeping changes in the way we will teach and train our future civil engineers. Since civil engineering and construction are closely related, and go hand in hand, it is important to review our current body of knowledge imparted in a four-year graduate of a construction degree program. It is equally important to devise a curriculum suited for a future construction professional that parallels the educational preparation of a future civil engineering graduate. This paper presents the basic

elements of a current four-year educational program for a construction professional, and compares with an educational program that would be more suited for a future construction professional. This paper presents a proactive approach to developing broad-based knowledge, requisite skills, attitudes, and integrity in a future construction graduate. It stresses understanding of issues such as 21st century global business economy, and multi-cultural teams; it also lays the foundation for strong understanding of world cultures, languages, and local practices in the context of international collaborations on small to mega construction projects. The future construction professional will be required to be grounded in ethical decision-making, and more versatile in life long learning aspirations. The future role of educators will continue to include characteristics such as scholarly faculty, effective teaching, and practice-oriented teaching and research. © American Society for Engineering Education, 2005.

1.2. Engineering Society Competitions and Conferences Incorporated in Curricula

Davids, L., et al. 2007. "The influence of hands-on female student project teams on the confidence of women engineering students." 114th Annual ASEE Conference and Exposition, 2007. American Society for Engineering Education.

Abstract: Based on recent statistics by the US Department of Labor, only 11 percent of aerospace engineers and only 5.6% of mechanical engineers are women[1]. Over 85% of the engineering students at Embry Riddle Aeronautical University are in one of these disciplines. Considering that 47% of the general US workforce is comprised of women, continued and increased efforts are needed to increase the number of women entering the engineering workforce. Like many institutions, Embry Riddle has struggled to attract women to our engineering programs. The university is working to increase female participation in all aspects of the engineering program. As shown in figure 1, a component of the multifaceted EmpoWER (Empowering Women at Embry Riddle) program to attract and retain young girls to the engineering field is to provide role female models to dispel the perception that engineering is a male dominated field. The EmpoWER project has the objective of increasing the number of women at all levels, including undergraduate students, graduate students and faculty. A component of this project is a hands-on all-female student design project. The purpose of this project is to provide a concrete representation of women engineers to prospective female students. Embry Riddle chose to field an all-female team for the Baja SAE competition. Other projects could also satisfy the EmpoWER project objectives. Female involvement in the Baja SAE design project has skyrocketed since the all-female team was established. In 2005-2006, roughly 20 women participated in the first year of the all-female project, which was 10 times the number of female students on the previous co-ed Baja SAE team. In 2006-2007, almost 80 women signed up for the project, which is almost 30% of the total number of female engineering students at Embry Riddle. © American Society for Engineering Education, 2007.

Schuster, P., et al. 2006. "Student competitions: The benefits and challenges." 113th Annual ASEE Conference and Exposition, 2006. American Society for Engineering Education.

Abstract: Intercollegiate design competitions are a popular means to engage students in design activities that extend beyond the curriculum. When students gather around a project in their spare time and use their classroom skills to design, build, and test a product for an intercollegiate competition, something amazing happens: They develop a passion for engineering. This paper discusses the key benefits to engineering undergraduate students that flow from involvement in a team design competition. Advisor involvement plays a key role in both project success and student learning throughout the process. Different approaches to advising student competition teams are compared. Specific examples are taken from the authors' experience with Formula SAE, SAE Mini Baja, and ASME's Human Powered Vehicle competitions. Responsibility for making the most effective educational use of a design competition is shared between the students, the faculty advisor, and the competition organizers. Design competitions build student enthusiasm; however, there are some things they learn that we may not want to be teaching. Some of the educational shortcomings of these activities are highlighted, with suggestions on how to manage them. In particular, this article focuses on the risks of (a) distraction from classes, (b) a build-and-test approach, (c) advisor co-opted designs, and (d) design changes for their own sake. The influence of the advisor and the competition rules on each of these concerns will be discussed. Finally, the competitions themselves will be investigated to see how the form of the events may be improved to further enhance the learning opportunities for the students. © American Society for Engineering Education, 2006.

Silverstein, D.L. 2005. "Making student conference trips an assessable learning opportunity." 2005 ASEE Annual Conference and Exposition. American Society for Engineering Education.

Abstract: The attendees at the 2003 and 2004 AIChE National Student Conferences were used to meet objectives for courses at all levels of the chemical engineering curriculum at the University of Kentucky Extended Campus Programs. Students from multiple courses were assigned roles as part of a start-up bio-tech or nano-tech company with indecisive management. Their role was to determine ahead of the conference a product or process in which the company should engage, keeping in mind the opportunities available at the conference. Upon their return, the teams of students prepared reports summarizing their proposal and findings, which were counted as homework assignments. © American Society for Engineering Education, 2005.

Stover, C. 2007. "SAE Collegiate Design projects as part of the engineering curriculum." 114th Annual ASEE Conference and Exposition, 2007. American Society for Engineering Education.

Abstract: The SAE Collegiate Design Series is a set of design competitions held throughout the world where undergraduate and graduate engineering students conceive, design, fabricate, and compete with student developed project vehicles. The restrictions on these vehicles are limited so that the knowledge, creativity, and imagination of the students are challenged. The projects are built with a team effort over a period of about one year and are taken to annual competitions for judging and comparison with a number of other vehicles from colleges and universities throughout the world. The result of these yearlong projects is a real world engineering experience for all students involved. Working within an interdisciplinary team environment from conception to completion gives our students a distinct advantage over others who have not been involved in extra curricular engineering project teams. The program benefits students in ways standard curricula cannot. The ability to work in a team environment, the ability to generate funding and support, and the hands on skills developed over the course of completing one of these projects has helped students both in their engineering abilities as well as their marketability after graduation. At our institution, students will come into the project at the freshman or sophomore level helping the team to complete some of the simpler tasks such as generating funding or physically wrenching on the projects. During their first few years, our SAE Project students are required to complete both a manufacturing engineering course as well as a machine tool applications class in order to be permitted to build and fabricate parts designed by upper division team members. Once our students reach the junior level, they apply for and are generally granted class credit for upper division technical elective credit for design and analysis work on their respective projects. The student's senior year involvement in the project is used as senior project or senior design credit in which they generally take on a more managerial role as lead engineers. In the course of their engineering education, our most involved students learn basic fabrication techniques, team and group project management, solid modeling and analysis techniques, and finish by producing, testing, and competing in a project that accurately reflects what they will come up against in real world engineering. This paper gives a general idea of how we have incorporated the SAE Collegiate Design Series competitions into our mechanical engineering curriculum. © American Society for Engineering Education, 2007.

Vavreck, A.N., et al. 2001. "Multidisciplinary multilevel functionally-managed student design in the SAE mini-Baja project." 2001 ASEE Annual Conference and Exposition. American Society for Engineering Education.

Abstract: In order to heed the call in engineering education to provide richer learning environments, in which engineering students develop critical skills to work effectively on teams with individuals from other fields, we need to encourage development of multidisciplinary, multilevel learning experiences in which students play lead roles. The Society of Automotive Engineers (SAE) Mini-Baja competition project at Penn State Altoona is one example of how faculty and students have been addressing this need. The project is structured as a functional organization, with students from many disciplines (engineering, engineering technology, business, English and art) engaged in supporting vehicle design, development and testing efforts. The student team, consisting of freshmen through seniors, are grouped by functional area (vehicle subsystem design, documentation, marketing, fabrication and testing) and coordinated by a "directorate" of upperclassmen. Students earn college credit for some of the activities, but the majority of the effort is on a volunteer basis. The project provides an excellent environment for cross-disciplinary learning, as well as team and project management skill development, and is an efficient way to carry on a major design effort. In addition, the project provides engineering research opportunities for one of the authors. The paper discusses the project organization in detail, and discusses the means and limitations of involving faculty and students from various disciplines in a broad integration of teaching, service to the profession and community, and research. © American Society for Engineering Education, 2001.

1.3.Partnerships, Training, Outreach, and Professional Development

Bogue, B., et al. 2013. "Professional societies making engineering outreach work: Good input results in good output." Leadersh. Manage. Eng. Leadership and Management in Engineering 13(1):11-26.

Staff description: This paper assesses engineering societies' outreach activities to children and young adults.

Delatte, N., et al. 2007. "Assessing the impact of case studies on the civil engineering and engineering mechanics curriculum." 114th Annual ASEE Conference and Exposition, 2007. American Society for Engineering Education.

Abstract: Engineers design. Engineering design uses mathematics and other principles, combined with judgment, to prevent failures. The lessons learned from failures have often led directly to changes to engineering codes and procedures. There is much that engineering students and engineers can learn from failures, and failures play an important role in engineering design. Therefore, there is a recognized need for failure awareness in the undergraduate engineering curriculum. This need has been documented in a number of papers and at a number of conferences over the past 15 years. This project is a specific response to that need, and will provide much needed access to thoroughly developed examples, and a heightened appreciation of the role failure analysis knowledge can play in higher education and public safety. The expected outcomes of this project will be educational materials on failure case studies for use in civil engineering and engineering mechanics courses, in print and CD-ROM format, and a series of three one-day workshops to disseminate those materials to engineering faculty members across the US, as well as a tested assessment package. The objectives of the project will be greater breadth of knowledge, greater depth of knowledge, and improved learning with a reasonable benefit/cost ratio for faculty. Although the majority of the work will be carried out at Cleveland State University, faculty members and practicing engineers from across the country will participate in the development of these materials and the workshop, through the various committees of the American Society of Civil Engineers (ASCE) Technical Council on Forensic Engineering (TCFE). Researchers from CSU College of Education will assist in assessing the impact of this project. Case studies require students to synthesize the facts and engineering principles they have learned, and combine them with their broader education in the arts, humanities, and sciences. These intellectual merits have been demonstrated so far with the students who have developed case studies under the proof-of-concept phase of this work. Case studies tie together technical aspects, ethical issues, and procedural issues, and require students to undertake higher order thinking in order to synthesize the relevant concepts. The case study products of this research will help civil engineering educators improve their teaching of specific technical topics within the discipline. In addition, the cases integrate ethics and procedural/professional issues into the courses. The broader impacts of the proposed activity will be the implementation of a set of fully developed case studies for civil engineering education. Based on survey returns from the participants selected for the pilot workshop, each of the 60 faculty can expect to directly influence an average of 3.2 courses and 215 students in the two years following workshop attendance. Thus, the broader impact will be approximately 190 courses and 13,000 students across the US. Furthermore, students will participate in this program developing case studies under the supervision of the faculty investigators. © American Society for Engineering Education, 2007.

Estey, J. 2005. "Vote and participate: Electronic option available." IEEE Power and Energy Magazine 3(4):10-11.

Staff description: This article on the IEEE Power Engineering Society (PES)'s election of officers highlights the importance of the organization in providing continuing education.

Ghafoori, N., and J.S. DeNatale. 1991. "ASCE's student chapters: Statistical analyses of key characteristics." Journal of Professional Issues in Engineering Education and Practice 117(3):267-274.

Abstract: Participation in a healthy and vibrant ASCE Student Chapter or Club enables a civil engineering undergraduate to become better prepared for professional practice. A survey of 230 ASCE Student Chapters and Clubs is conducted to determine: (1) Student Chapter demographics; (2) the characteristics of the academic environments within which the Chapters operate; and (3) the perceptions held by Chapter and Club advisors regarding their various responsibilities and roles. Chi-square analyses are performed to establish whether significant relations exist between any of these characteristics and perceptions. The results of this survey suggest that ASCE's student organizations and advisory personnel share a common set of roles and goals that is largely independent of the academic environment. © American Society of Civil Engineers, 1991.

(Also an example of K-12 education) Gorham, D. 2006. "Work In Progress: A Pre-University Engineering Education Partnership with Engineering Societies, Educator Associations and Industry." Frontiers in Education Conference, 36th Annual. Institute of Electrical and Electronics Engineers.

Staff description: This paper describes IEEE's initiative to promote engineering to pre-university educators. The paper specifically looks at the partnerships involved in the Center for Pre-University Engineering Education and the TryEngineering.org website.

Martin, S., et al. 2010. "Engineering societies as a vehicle tool for engineering students." Education Engineering (EDUCON), 2010. Institute of Electrical and Electronics Engineers.

Staff description: This paper describes the role of student chapters ("branches") in engineering education and illustrates the importance of student chapters using the example of the IEEE Student Branch of UNED (Spanish University for Distance Education).

Newell, D.C., et al. 2004. "The Coalition of Minority Engineering Societies and The Society of Women Engineers (CEMSWE): Collaborative retention efforts with INTEL." Frontiers in Education, 2004. FIE 2004. 34th Annual. Institute of Electrical and Electronics Engineers.

Staff description: This paper describes the activities of the Coalition of Engineering Minority Societies and the Society of Women Engineers (CEMSWE) and its operating entity, the Center for Engineering Diversity and Retention (CEDAR). The paper looks specifically at their collaboration with INTEL and discusses how the program could be used by other companies.

Schulz, N.N., et al. 2002. "Women in power: Networking on & off campus." 2002 ASEE Annual Conference and Exposition. American Society for Engineering Education.

Abstract: While many universities have had some success in increasing the enrollment of women in graduate and undergraduate classes, they still struggle to increase the number of women faculty in their engineering departments. Besides challenges in recruitment, departments must also worry about retention of their women faculty especially since many departments may only have one or two women faculty. Isolationism can play a major role in women faculty leaving a university. One of the solutions for successful retention and recruitment of women faculty (and all faculty) is to get them involved in a "network" so they feel part of the department, college, university or technical community. This paper will discuss networking opportunities for women faculty both on their home campuses as well as at technical meetings. Women faculty in power engineering from three different schools, Mississippi State, Texas A&M and Missouri-Rolla, will discuss their activities on campus including both formal and informal networking opportunities for women faculty. Additionally they will discuss how activities at IEEE Power Engineering Society meetings provide them with off-campus networking opportunities in their specific technical area. The paper will outline how these networking groups started, suggestions for others and lessons learned.
© American Society for Engineering Education, 2002.

1.4. Engineering Society Student Chapter Involvement

Burtner, J., and R. Rogge. 2003. "Faculty advisors' management style and the development of students' leadership capabilities." 2003 ASEE Annual Conference and Exposition. American Society for Engineering Education.

Abstract: The Mercer University chapter of the Society of Women Engineers (SWE) received its charter in October 1992. The two authors have each served as advisors to the SWE group, and have observed that the duties of the faculty advisor to a student organization are not well defined and often need to be adjusted based on the personalities and leadership experience of the officers. This can be frustrating for faculty advisors, even experienced ones, as the role they must play changes from year to year. The situation is complicated further when the most appropriate leadership role conflicts with the management style of the faculty advisor. This paper serves as a case study of management styles and leadership roles in a voluntary organization and explores reasons for potential successes and failures. © American Society for Engineering Education, 2003.

Byam, B.P. 2002. “An enhanced educational experience for capstone design projects: Using SAE student groups in an industry sponsor role.” 2002 ASEE Annual Conference and Exposition. American Society for Engineering Education.

Abstract: The Mechanical Engineering Department at Saginaw Valley State University (SVSU) is enhancing the educational experience of students by using Society of Automotive Engineers (SAE) student groups in the role of industry sponsor for capstone design projects. In many engineering programs, industry sponsors are used as a resource for capstone design projects. This format involves many institutional and educational benefits and challenges. Industry sponsors provide capstone design students with a project that includes a problem definition, domain knowledge, possible funding, and possible facilities. Capstone students work in a team on the project, experiencing the technical, teamwork, leadership, political, and emotional aspects of the design process. The institution provides advanced technical and, sometimes, entrepreneurial outreach to the region. Using SAE student groups in an industry sponsor role enhances the education experience in many ways. The SAE student group gains the experience of managing an engineering project by providing the problem definition, prioritizing groups, choosing the projects to outsource, establishing budgets, setting deadlines, allocating resources, and supplying the domain knowledge. Capstone students involved in these projects experience all the highs and lows of these challenges. The SAE student group sees the benefits from a form of outreach. Using SAE student groups in the industry sponsor role exposes SVSU engineering students to a broader design process experience, thus enhancing their education. © American Society for Engineering Education, 2002.

(Also an example of K-12 education) Ciston, S., et al. 2010. “Summer Technology and Engineering Program: An outreach program benefitting women engineering students from middle school through graduate school.” 2010 ASEE Annual Conference and Exposition. American Society for Engineering Education.

Abstract: The Summer Technology and Engineering Program (STEP) is hosted by the Society of Women Engineers student chapter at Northwestern University, and invites girls in 7th and 8th grade to explore engineering disciplines and envision themselves as future engineers. The participants work closely with undergraduate and graduate student mentors from engineering to do hands-on activities from across multiple engineering disciplines. This experience results in positive outcomes for women students involved at all levels. Girls find supportive role models in the SWE women, and mentoring relationships have developed. This presentation will describe the program, and discuss results of post-program surveys of middle school, undergraduate, and graduate students to show the impacts of the program on these various groups, and to provide a model for similar programs. © American Society for Engineering Education, 2010.

Conley, C., et al. 2006. “ASCE student chapters: A contributor to achieving program goals.” 2006 ASEE Annual Conference and Exposition. American Society for Engineering Education.

Abstract: An analysis is presented of the American Society of Civil Engineers (ASCE) Policy 465 outcomes, their origins, and the ways an ASCE Student Chapter could contribute to their attainment. The authors draw on their experience serving on ASCE’s Committee on Student Activities, working with student chapters and clubs, and serving on the ASCE’s Second Edition of the Body of Knowledge Committee. Using their experience from reviewing student chapter and club annual reports from many schools over several years, from attending and observing numerous Regional Student Conferences, from running Workshops for Student Chapter Leaders, from participating in Practitioner and Faculty Advisor Training Workshops, and finally from serving as advisor for the USMA student chapter, the authors assess the contribution of student groups to attainment of Policy 465 outcomes. Through community service projects, field trips, guest speakers, organizing and running local, regional and in some cases national events, and through the leadership opportunities offered in the ASCE student groups, civil engineering undergraduates can, and do, demonstrate that they are developing the skills and gaining experience in many of the areas outlined in the 15 outcomes of the BOK. When the student group has faculty and practitioner advisor participation, and takes on significant service projects and/or the running of events involving large numbers of participants, the learning and experience are at their best. The educational opportunities presented by an active and well run ASCE student group cannot be matched in traditional classroom settings. In examining recent initiatives of the National Academy of Engineering (NAE) regarding the future of engineering education, it is clear that many typical ASCE student group activities can contribute to meeting the recommendations of the NAE immediately, without significant changes to a program’s curriculum. Finally, ASCE student group activities can also be used to support civil engineering program accreditation, under both current and proposed criteria. © American Society for Engineering Education, 2006.

Du Maine, J.J., et al. 2003. “Affinity groups: More bang for the buck.” 2003 ASEE Annual Conference and Exposition. American Society for Engineering Education.

Abstract: The role of affinity groups in the persistence of women and minority engineering students by providing exposure to the field as well as opportunities to enhance the self-confidence of the student is discussed. St. Louis Community College at Florissant Valley was the first community college in the country to obtain a student chapter in the National Society of Black Engineers. The value of this organization, the process of achieving this recognition and the accomplishments of the students since 1999 are also discussed. Through such affinity groups, students forge stronger relationships with faculty and tend to become more involved with the campus. © American Society for Engineering Education, 2003.

Durham, S.A., and W.E. Marshall. 2012. “Enhancing a student’s engineering experience through participation on student organizations.” 119th ASEE Annual Conference and Exposition, 2012. American Society for Engineering Education.

Abstract: Numerous engineering related student organizations exist at colleges throughout the United States. Student organizations such as the American Society of Civil Engineers (ASCE) American Concrete Institute (ACI) Institute of Transportation Engineers (ITE), Society of Hispanic Professional Engineers (SHPE), Society of Women Engineers (SWE), and many others help produce better engineers who are more prepared for entry level positions upon graduation. These student led, faculty advised, groups provide opportunities for students to take on a leadership role in an

organization, develop study groups with other members, connect with industry professionals, and participate on a design team. Most student organizations are typically led by the top students within an engineering program. Typically, there is a president, vice president, secretary, and treasurer for each of these student groups. The responsibilities for each of these positions provide students with leadership skills that will later be used in engineering practice upon graduation. Other valuable aspects of these organizations are the projects that are performed within each. For example, many organizations participate in regional and national design competitions, such as the ASCE Concrete Canoe and Steel Bridge Competition, while other groups assist their own schools or municipalities with engineering projects or data collection efforts. Another important source of hands-on experience for these student groups is often found through volunteering on community service projects such as Habitat for Humanity or park clean-ups. Regardless of whether the projects are competitive or not, they all have an important role in enhancing a student's engineering education experience. While some projects help students combine classroom learning (i.e. steel design) with real world applications (i.e. steel bridge design, fabrication, and construction), other projects help introduce the many socio-economic aspects of engineering through a participatory process. These organizations provide a great opportunity for undergraduate students to form collaborative study groups. Because these organizations are comprised of students in all classes, freshmen through seniors and even graduate students, students are able to work with other students to study for exams and assist in the understanding of homework problems and course content. Lastly, guest speakers are routinely incorporated into regularly scheduled organizational meetings. These speakers are often industry professionals, local officials, and career development staff. Roundtable discussions between student group members and a panel of young engineers are great ways for students to ask questions about career opportunities, expectations, interview insights, and other queries students may have about school, jobs, and career paths. Such informal meetings with local professionals are good networking opportunities for students, from which internships and job opportunities occasionally materialize. This paper summarizes the co-benefits of student organizations in engineering programs. Student participation in these groups can greatly enhance the overall undergraduate educational experience and ultimately lead to students being better prepared for entry-level engineering jobs and beyond. © American Society for Engineering Education, 2012.

Eschenbach, E.A., and E.M. Cashman. 2004. "Go with the flow: A student leadership opportunity integrating K-12 outreach, the society of women engineers, service learning and peer mentoring." <u>ASEE 2004 Annual Conference and Exposition</u>. American Society for Engineering Education.

Abstract: This paper describes a multi-year project that involved the Humboldt State University Student Section of the Society of Women Engineers in a Service Learning project that now serves as a continuous outreach project to young children in the community. The SWE club oversaw the design, construction and use of a child sized flume for study of water physics that is now on display at a local children's science museum. Students in 3 different engineering classes that were offered repeatedly over 5 semesters were directly impacted by the project. Engineering students in a fluid mechanics class designed the flume via a SWE supported design competition. The SWE club then raised funds for the construction of the flume, which was built by the engineering department technician. The project was integrated into two other engineering courses in such a manner that senior engineering students worked with first year students as part of the same project. SWE members as well as other engineering students then took the flume to local schools and outreach events. The SWE students experienced fund raising, project management, and teaching K-12th grade physical science concepts. K-12th grade students were exposed to female engineering role models. Over 150 engineering students, as well as 3 engineering faculty were involved in the project in some capacity. 750 local children were exposed to the flume during SWE outreach activities. This project model could be used in other fields of engineering. This project incorporates K-12 outreach, Service Learning, peer mentoring and extracurricular service. © American Society for Engineering Education, 2004.

Fear, E.C. 1999. “Student opportunities in the Engineering in Medicine and Biology Society.” Proceedings of the First Joint BMES/EMBS Conference, 1999. Institute of Electrical and Electronics Engineers.

Staff description: This paper describes the educational activities of the Engineering in Medicine and Biology Society (EMBS) including limited statistics on student membership and a discussion of the problems of communicating with members.

Larson, R. 2008. “A snapshot of success: How student-initiated automotive design became integrated into the ME and MET curricula.” 2008 ASEE Annual Conference and Exposition. American Society for Engineering Education.

Abstract: A fascinating relationship has evolved within our Mechanical and Industrial Engineering Department. Three years ago, students initiated the formation of a campus motor-sports club and formed an SAE chapter to pursue participation in the Formula SAE race series. Over the brief period since club inception, the activities of this group have transitioned into core elements of upper-division ME and MET coursework. The club has retained a significant portion of required fund-raising, as well as the responsibility for dictating vehicle specifications. The core of the student club-to-coursework relationship occurs in the interdisciplinary (ME and MET) Capstone Design course. Club-sponsored automotive design and build projects are treated essentially as any other industry-sponsored project, with the twist that they are funded primarily by students who are primarily enrolled in either the ME or MET curriculum. Many of the students fill dual roles: That is, they help define the projects in their role as club members and are then enlisted by course instructors to design/build/test the components as members of the design teams working, resulting in a course grade. This scenario has resulted in a level of student involvement in - and enthusiasm for - the engineering education process that has rarely been seen before at this university. Students are absolutely engaged in a broad spectrum of their education: They define the project, specify technical elements, raise money for materials & purchased components, design, fabricate and test. Then as club members they race the vehicles produced for recreation and enjoyment. Initially the interactions between club and ME/MET courses occurred through the inter-disciplinary capstone design course, but this activity has grown to involve courses in advanced instrumentation, composite materials, tooling, advanced CAD, and other coursework. This paper describes the present state of our Formula SAE race car project, the interactions between the student SAE club and the ME/MET courses participating in the relationship, and the path taken to arrive here. Positive and negative aspects of the relationship between the student club and required coursework are examined, and some guidelines and recommendations for the future are shared. © American Society for Engineering Education, 2008.

Lasich, D., and C. Sulzbach. 2008. “The role of institutional commitment in the utilization of collegiate SWE sections as a recruitment and retention strategy.” 2008 ASEE Annual Conference and Exposition. American Society for Engineering Education.

Abstract: Women currently make up 56% of the undergraduate student population in the United States, but only comprise 17.4% of engineering undergraduate programs. In response to this fact,

many science and engineering colleges have indicated that they want to increase the number of women on campus, but often do not provide the infrastructure to achieve this goal. To successfully recruit and retain female students in these fields, some of the more effective methods often include a strong commitment at the institutional level rather than making it the responsibility of a single department, organization, or office. At Colorado School of Mines (CSM), an example of this approach involves utilizing the many assets of their Society of Women Engineers (SWE) collegiate section, which include their members, activities, and corporate contacts, to attract women to the institution, as well as retain them once they enroll. Colorado School of Mines has had an active and successful SWE section since it began in 1978. Starting with just a few students, it has grown to over 360 members and is the 3rd largest section in the nation. In the fall of 2002, the new Society of Women Engineers (SWE) faculty advisor and the Executive Director for the Women in Science, Engineering and Mathematics (WISEM) Program recognized that the organization could be a vital resource in recruiting and retaining female students at CSM. They began working on developing partnerships with decision makers and key personnel in the areas of Academic Affairs, Student Affairs, Admissions, Career Services, Institutional Advancement and the Engineering Division. By doing so, they were able to secure both the institutional commitment and the financial resources needed to provide prospective and enrolled female students with the information, opportunities, and academic and professional development needed for women to feel part of a connected learning environment. Because of efforts like this, combined with other institutional recruitment and retention strategies, female undergraduate students at CSM continue to persist and graduate at a higher rate than their male counterparts, and the number of undergraduate and total female undergraduate students enrolled has been trending upward for more than 10 years. © American Society for Engineering Education, 2008.

Storace, H., et al. 2005. "The building of the top national mid-size SWE student section." 2005 ASEE Annual Conference and Exposition. American Society for Engineering Education.

Abstract: The Society of Women Engineers (SWE) Student Section, established in 1976 at Arizona State University (ASU), struggled for most of its history. The strength of the organization fluctuated greatly with the strength of the student leaders that would come and go. During the last several years, however, the Section has developed a strong management system using industrial engineering principles, strong student involvement, and played a proactive role in the recruitment and retention of women in the Fulton School of Engineering. After SWE student officers attended the Student Awards Banquet at the SWE National Conference in the fall of 2002, they vowed to be named the top Mid-size SWE Student Section for 2003. The Section created a management team of 25 women who led many recruitment and retention events. Over the past two years, there have been modifications to the Leadership Team based on the Section needs and now there are approximately 30 officers (executive board, five committees, and representative positions). The Section realized their goal in October 2003 by winning five national awards including top mid-size section in the nation! The authors will describe how and why the Section grew in members, its activities, and how its management system came to be. They will also discuss how the organization is developing leaders, increasing interest in engineering, and helping to retain women engineering students in the Fulton School of Engineering. © American Society for Engineering Education, 2005.

Yunfeng, W., and M. Mie. 2003. "BME education program at the EMBS student club of Beijing University of Posts and Telecommunications." Engineering in Medicine and Biology Society, 2003. Proceedings of the 25th Annual International Conference of the IEEE. Institute of Electrical and Electronics Engineers.

Staff description: This paper describes the activities of the Engineering in Medicine and Biology Society (EMBS) Student Club of Beijing University of Posts and Telecommunications (BUPT), including fund raising, lectures and seminars, team-based research, community events, and development of an ethics code.

2. Examples of Evaluation of Engineering Society Impact on Engineering Education

Bielefeldt, A. 2010. "Student perceptions of the Civil Engineering Body of Knowledge." 2010 ASEE Annual Conference and Exposition. American Society for Engineering Education.

Abstract: It is of interest to determine how civil engineering students perceive the educational outcome requirements articulated in the American Society of Civil Engineers Body of Knowledge (BOK2). Therefore, freshmen and senior civil engineering (CVEN) students at the University of Colorado at Boulder (CU) were introduced to the BOK2 and asked for feedback. Students in a first year Introduction to Civil Engineering course were provided with the BOK in 2008 and 2009. They were encouraged to use the information on the first homework assignment to define civil engineering and the skills required to be a civil engineer. The students articulated which five skills and abilities they thought were the most important to be a civil engineer and three skill areas that were unique to civil engineering compared to other engineering disciplines. At the end of the semester the students were asked to comment on their personal strengths and weaknesses in regards to the outcome skills in ABET and/or the BOK2. In addition, ~65 senior civil engineering students ranked the importance, curriculum weaknesses, and personal weaknesses in the BOK2 outcomes. The freshman and senior responses in regards to the most important skills were significantly different, with the exception of the relative importance of design and math. In addition, five senior civil engineering students mapped their personal course experiences to the BOK2. One student noted that the capstone design course alone covered 21 of the 24 BOK2 outcomes, indicating that a single course can achieve a wide range of objectives and one need not view the BOK2 outcomes as "course-by-course" requirements. However, the outcomes in the senior design course were somewhat dependent on the specific project and the individual students' role on the project. For example, a service learning project for a developing community achieved to some extent the globalization outcome that other students noted was lacking. This approach of using "rich" pedagogy and learning experiences will be necessary to achieve the requirements in the BOK2. Student feedback on the BOK2 may indicate where curriculum changes in a specific program are needed, and/or may be useful indicators of what aspects of the profession may be appealing to students who are underrepresented in civil engineering (females and minorities). © American Society for Engineering Education, 2010.

Chowdhury, S., et al. 2007. "Capstone design course as a tool for assessment and improvement." 114th Annual ASEE Conference and Exposition, 2007. American Society for Engineering Education.

Abstract: This paper discusses the role of the Capstone Design course in achieving the goal of the Mechanical Engineering (ME) Program at Alabama A&M University. The course is mapped to the ME Program educational objective and expected outcomes, as well as to the Accreditation Board for Engineering and Technology (ABET) criteria and some additional ME Program criteria based on the requirements by the American Society of Mechanical Engineers. The program outcomes should be measurable, and so an assessment tool or Survey has been developed. The survey form is completed by the students at the end of the second semester of the Capstone Design course, along with their

final project report. Evaluations by the instructors are also completed. The student survey results and faculty evaluations are compiled and compared with the above mentioned course mapping. The results show that there is considerable matching between the course mapping for the expected educational outcomes done by the faculty, and the survey completed by the graduating students in this respect. This serves as a tool for measuring the accomplishment of ABET requirements. The results also give some feedback for possible improvement in future. The Capstone Design course also serves to prepare the students to succeed as entry-level engineers in industry, by acquiring technical design experience for appropriate careers. The students are required to make several oral presentations with audio-visual aids (using PowerPoint) about their project in front of the faculty and peers, during the semester. A Project Oral Presentation Evaluation Form has been developed which is completed by the faculty and peers during each presentation. The results are compiled and analyzed. The results show that there is significant (over 20%) improvement in the student performance due to this continuous evaluation by the faculty and peers. The Capstone Design course uses the knowledge learned by the students in various academic courses, and trains them how to complete a project as an engineer utilizing that knowledge. It also teaches the student to work effectively in a team, which is one of the top requirements of Best Practices for new BS graduate engineers by industry. By preparing the students to be successful engineers, the Capstone Design course improves student retention and will help to increase the percentage of minority black engineers in future. © American Society for Engineering Education, 2007.

Koehn, E., et al. 2006. Body of Knowledge (BOK) outcomes in an ABET curriculum. American Society for Engineering Education, 2006.

Abstract: The American Society of Civil Engineers (ASCE) has adopted Policy Statement 465 in recognition of the increasing complexity of civil engineering practice and the general tendency for schools to reduce the credit hours required for graduation. The Body of Knowledge (BOK) required to support the policy statement was also discussed. The BOK recommendations include 15 outcomes which are designed to broaden and deepen the 11 current outcomes required by the Accreditation Board for Engineering and Technology (ABET). This paper presents data that indicate civil engineering programs at the bachelor's level may presently be satisfying, to some degree, 14 of the 15 BOK outcomes. These include the 11 ABET outcomes in addition to the following: (13) An understanding of the elements of project management, construction, and asset management. (14) An understanding of business and public policy and administration fundamentals. (15) An understanding of the role of the leader and leadership principles and attitudes. It is hoped that the knowledge gained with the BOK assists the students in their future endeavors as they become alumni practitioners. However, outcome 12, an ability to apply knowledge in a specialized area related to civil engineering, is difficult to satisfy in a normal undergraduate civil engineering program. Nevertheless, for comparative purposes, the findings of this investigation could be utilized by other institutions and departments that may wish to study their curriculum and/or develop a system of evaluation to measure the achievement of BOK outcomes. © American Society for Engineering Education, 2006.

3. General Engineering Education or Engineering Society Reports

Allendoerfer, C., et al. 2012. "Strategic pathways for success: The influence of outside community on academic engagement." Journal of Engineering Education 101(3):512-538.

Background: Engineering students participate in a variety of communities outside of their academic endeavors ranging from family to professional societies. While the degree to which they participate and immediate benefits of participation have been explored, pathways by which participation in nonacademic "outside" communities leads to academic engagement are not as well understood. Purpose (Hypothesis): This study seeks to identify outside communities to which students feel most connected and pathways by which these important communities influence students' academic endeavors. Design/Method: This study uses mixed methods, combining surveys and focus groups. A survey emphasizing measurement of belonging, engagement, and connection to community was collected from over 750 student participants at four different institutions. Focus groups were then used to explore how students' most important communities influence their academic life. Focus group data analysis revealed which needs were met for students through participation in outside communities. Results: Across all institutions, family is the community to which students feel most connected, with friends being a distant second. Students spoke of communities strategically, identifying needs that they meet through participation in communities and linking their participation with increased ability to engage in their academic endeavors. Most frequently, students' belonging needs were met through participation in outside communities, although safety and esteem needs were also affected. Conclusions: Our results strongly suggest that, among the many types of needs studied, providing students with opportunities to belong will provide the most return on investment for engagement in academic endeavors. © American Society for Engineering Education, 2012.

Burt, B.A., et al. 2011. "Outcomes of engaging engineering undergraduates in co-curricular experiences." 2011 ASEE Annual Conference and Exposition. American Society for Engineering Education.

Abstract: The effects of involvement in co-curricular experiences (i.e. internships, co-ops, service projects, and clubs and organizations) on student persistence in college is well documented in the education literature. What remains unclear are the specific ways that involvement influences the development of engineering undergraduate students. We found that when engineering students are involved in co-curricular experiences they exhibit greater leadership skills, are more thoughtful about their ethical decisions, and can articulate how involvement influences their ethical development. In this paper, we explore outcomes of participating in co-curricular experiences for engineering students at four undergraduate focused institutions. © American Society for Engineering Education, 2011.

Davis, M.T. 2001. "Shaping the future of our profession." Technical Communication 48(2):139-144.

Staff description: This article looks at how technical communication can achieve a higher level of professionalism by following the example set by medicine and engineering, including through academic standard setting by professional societies.

Finelli, C.J., et al. 2012. "An assessment of engineering students' curricular and co-curricular experiences and their ethical development." Journal of Engineering Education 101(3):469-494.

Background: Ethics instruction is an important component of engineering undergraduate education, but little research has identified aspects of the undergraduate experience that contribute most to students' ethical development. Thus, an assessment of the impact of students' experiences on their ethical development is warranted. Purpose (Hypothesis): We apply a conceptual framework to the study of engineering students' ethical development. This framework suggests that both formal curricular experiences and co-curricular experiences are related to students' ethical development. Design/Method Using survey data collected from nearly 4,000 engineering undergraduates at 18 institutions across the US, we present descriptive statistics related to students' formal curricular experiences and their co-curricular experiences. Additionally, we present data for three constructs of ethical development (knowledge of ethics, ethical reasoning, and ethical behavior). Results: For our sample, the quantity and quality of students' formal curricular experiences and their co-curricular experiences related to ethics was high. The levels of ethical knowledge and reasoning varied, as did ethical behavior. Conclusions: Our data highlight opportunities for improving the engineering undergraduate/bachelor's level curricula in order to have a greater impact on students' ethical development. We suggest that institutions integrate ethics instruction throughout the formal curriculum, support use of varied approaches that foster high-quality experiences, and leverage both influences of co-curricular experiences and students' desires to engage in positive ethical behaviors. © American Society for Engineering Education, 2012.

Fisher, D.R. 2013. Educating Engineers for the 21st Century: A Framework for Skill Development through Co-Curricular and Extracurricular Involvement. Massachusetts Institute of Technology.

Staff description: This master's thesis looks at how student cocurricular and extracurricular activities promote the development of leadership and professional skills.

Fisher, D.R., et al. 2014. "Fostering 21st century skills in engineering undergraduates through co-curricular involvement." 2014 ASEE Annual Conference and Exposition. American Society for Engineering Education.

Abstract: As engineering institutions attempt to prepare their students for today's global, cross-disciplinary workplace, incorporation of 21st century "soft" skills into classroom-based engineering education has become the practice of many colleges and universities in the United States and elsewhere. While this method may prove effective in many cases, this paper presents an alternative approach to fostering these skills in engineering education: student skill development through cocurricular involvement. For this analysis, we focus on undergraduate engineering education, as we ground our framework in the existing student affairs literature on the benefits of undergraduate student involvement. While this literature thoroughly examines the benefits of co-curricular engagement on the wide community of undergraduates, few existing studies examine the impact of this phenomenon through an engineering education lens. The purpose of this research is to create a framework categorizing how specific types of student involvement - such as engagement in the arts, athletics, or student government organizations - can impact competency development in undergraduate engineering students. To accomplish this goal, this paper draws upon an extensive review of student involvement literature to develop a framework of the skills and attributes developed through specific categories of undergraduate cocurricular involvement organized through a case analysis of student clubs at the Massachusetts Institute of Technology (MIT). The connection of this framework to engineering education is then validated through interview data collected from supervisors of entry-level engineering graduates. Based on this validation analysis, 19 skills and attributes relevant to engineering education and practice are shown to be developed through co-curricular involvement at the undergraduate level; based on these findings, the authors propose recommendations for administrators at undergraduate technical institutions regarding expanded support of co-curricular activities for undergraduate engineering students. © American Society for Engineering Education, 2014.

Jamieson, L.H., and J.R. Lohmann. 2009. Creating a Culture for Scholarly and Systematic Innovation in Engineering Education: Ensuring US Engineering Has the Right People with the Right Talent for a Global Society. American Society for Engineering Education.

Abstract: This is the first of two reports from an initiative by the American Society for Engineering Education to advance US engineering educational innovation. We know that how we teach is as important as what we teach. High-quality educational environments are the result of attention to both content and learning. This report is neither about the skills, abilities, or attitudes needed to be the next generation engineer nor about how people learn per se. Many thoughtful reports already focus on these issues. This report connects these two bodies of knowledge by addressing a fundamental question: How do we create an environment in which many exciting, engaging, and empowering engineering educational innovations can flourish and make a significant difference in educating future engineers? The purpose of this report, therefore, is to catalyze a conversation in the US engineering community on creating and sustaining a vibrant engineering academic culture for scholarly and systematic educational innovation—just as we have for technological innovation—to ensure that the US engineering profession has the right people with the right talent for a global society. © American Society for Engineering Education, 2009.

Litzler, E., and C. Samuelson. 2013. "How underrepresented minority engineering students derive a sense of belonging from engineering." 2013 ASEE Annual Conference and Exposition. American Society for Engineering Education.

Abstract: While feeling overwhelmed by the workload, pace and conceptual difficulties can be a common experience among undergraduate engineering students, ethnic minority engineering students often face additional challenges in their undergraduate programs, which can make them feel isolated and hinder their ability to integrate into their college campuses. Integration into the college environment plays an important role in students feeling a sense of belonging on campus, and ultimately in their decisions to persist. Racial and ethnic minority students who are integrated into the college environment through various means can find supports such as friends with similar backgrounds, advice from advanced students, and role models and advisors, which can positively influence academic performance. This paper identifies four main areas which under-represented minority students in engineering described as helpful to their development of a sense of community and belonging: co-curricular/extracurricular. © American Society for Engineering Education, 2013.

NAE [National Academy of Engineering]. 2005. Educating the Engineer of 2020: Adapting Engineering Education to the New Century. Washington: National Academies Press.

Summary: Educating the Engineer of 2020 is grounded by the observations, questions, and conclusions presented in the best-selling book The Engineer of 2020: Visions of Engineering in the New Century. This book offers recommendations on how to enrich and broaden engineering education so graduates are better prepared to work in a constantly changing global economy. It notes the importance of improving recruitment and retention of students and making the learning experience more meaningful to them. It also discusses the value of considering changes in engineering education in the broader context of enhancing the status of the engineering profession and improving the public understanding of engineering. Although certain basics of engineering will not change in the future, the explosion of knowledge, the global economy, and the way engineers work will reflect an ongoing evolution. If the United States is to maintain its economic leadership and be able to sustain its share of high-technology jobs, it must prepare for this wave of change. The report also recognizes the important role professional societies play and should play in engineering education.

Rathod, M., and M.J. Legatski. 2006. “A perspective on initiatives in diversity and outreach activities of ASME, an international society.” 2013 ASEE Annual Conference and Exposition. American Society for Engineering Education.

Abstract: For our global community and diverse workforce, respecting, recognizing, and understanding diversity and being inclusive are of the utmost importance for our success. Professional societies can provide an important venue and role model for others to follow. During the period 2002-05, the authors served in leadership positions of a board on diversity and outreach at the American Society of Mechanical Engineers, an international professional society with more than 100,000 members and in 2005 it celebrated the 125th anniversary of its founding. This paper describes that board’s some of successful and emerging programs, as well as the impact of the board’s actions on the society as it attempts to grow and reach out to members in a global setting. A brief description of topics to be addressed include board membership that can make an impact, organizing diversity forums, successful student chapter organized activities, mentoring program for young under-represented members, activities organized by senior members, outreach to minority and women professional societies, and the leadership’s recognition of the crucial role that diversity and outreach play in organizational success. A perspective from the authors’ point of view concludes the paper. It describes lessons learned and not learned while trying to make an impact in an international setting. As professions grow globally, a model containing diversity as a business case is presented for other societies and organizations to follow. © American Society for Engineering Education, 2006.

Kober, N., et al. 2015. Reaching Students: What Research Says about Effective Instruction in Undergraduate Science and Engineering. Washington: National Academies Press.

Summary: The undergraduate years are a turning point in producing scientifically literate citizens and future scientists and engineers. Evidence from research about how students learn science and engineering shows that teaching strategies that motivate and engage students will improve their learning. So how do students best learn science and engineering? Are there ways of thinking that hinder or help their learning process? Which teaching strategies are most effective in developing their knowledge and skills? And how can practitioners apply these strategies to their own courses or suggest new approaches within their departments or institutions? Reaching Students strives to answer these questions. Reaching Students presents the best thinking to date on teaching and learning undergraduate science and engineering. Focusing on the disciplines of astronomy, biology, chemistry, engineering, geosciences, and physics, this book is an introduction to strategies to try in your classroom or institution. Concrete examples and case studies illustrate how experienced instructors and leaders have applied evidence-based approaches to address student needs, encouraged the use of effective techniques within a department or an institution, and addressed the challenges that arose along the way. The research-based strategies in Reaching Students can be adopted or adapted by instructors and leaders in all types of public or private higher education institutions. They are designed to work in introductory and upper-level courses, small and large classes, lectures and labs, and courses for majors and non-majors., and these approaches are feasible for practitioners of all experience levels who are open to incorporating ideas from research and reflecting on their teaching practices. This book is an essential resource for enriching instruction and better educating students.

Siller, T.J., et al. 2009. “Development of undergraduate students’ professional skills.” Journal of Professional Issues in Engineering Education and Practice 135(3):102-108.

Abstract: The development of engineering students' professional skills has gained considerable national attention from Accreditation Board for Engineering and Technology, the National Academy of Engineering, ASCE, and other constituents. There is little debate that these professional skills are necessary. Engineering programs have tried many approaches to develop these skills in the undergraduate programs. Colorado State University (CSU) has developed a new approach modeled on the type of professional development that occurs in the professional environment. This new Professional Learning Institute (PLI) provides students with a broad array of workshops, presentations, and experiential opportunities addressing the areas of cross cultural communication and teamwork, innovation, leadership, ethics, and public service. This program introduces students to the concept of professional development through required extracurricular activities, includes minimum requirements along with requirements to earn certificates in specialty areas for motivated students. The majority of offerings in the PLI are presented by leaders from the engineering profession who have teamed with CSU to provide high quality programs for our students. © American Society for Engineering Education, 2009.

Wilson, D., et al. 2014. "The link between cocurricular activities and academic engagement in engineering education." Journal of Engineering Education 103(4):625-651.

Background: Cocurricular and extracurricular activities benefit precollege students. Yet connections between these activities and academic outcomes in college are mixed or inconclusive. Little is known about how involvement in cocurricular activities is associated specifically with academic engagement in college. Purpose (Hypothesis): The purpose of this study was to understand the connection between cocurricular activities and academic engagement for engineering and computer science undergraduates. We hypothesized that cocurricular activities and engagement are not directly related but are associated with one another through interactions with academic self-efficacy. Design/Method: This study surveyed engineering and computer science students at four different institutions. Data were analyzed using multiple linear regression models to understand the relationships between cocurricular activities and academic engagement. Results: While relationships between cocurricular activities and academic engagement were not significant, interaction effects with academic self-efficacy were significant. Academic cocurricular activities interacted positively with, whereas nonacademic cocurricular activities interacted negatively with, relationships between self-efficacy and academic engagement. Conclusions Results show that connections between cocurricular involvement and academic engagement not only occur in interactions with self-efficacy, but also depend on the nature of the cocurricular activity. Most students who are active in cocurricular activities report higher levels of engagement than do their nonactive peers for the same levels of self-efficacy. © American Society for Engineering Education, 2014.