
AC 2011-2667: HOW THE NEW ARCHITECTURAL ENGINEERING PROGRAM CRITERIA DIFFERS FROM THE NEW CIVIL ENGINEERING PROGRAM CRITERIA

Allen C Estes, California Polytechnic State University

Allen C. Estes is a Professor and Head for the Architectural Engineering Department at California Polytechnic State University in San Luis Obispo. Until January 2007, Dr. Estes was the Director of the Civil Engineering Program at the United States Military Academy (USMA). He is a registered Professional Engineer in Virginia. Al Estes received a B.S. degree from USMA in 1978, M.S. degrees in Structural Engineering and in Construction Management from Stanford University in 1987 and a Ph.D. degree in Civil Engineering from the University of Colorado at Boulder in 1997.

How the New Architectural Engineering Program Criteria Differs From the New Civil Engineering Program Criteria

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.

Introduction

Seventeen architectural engineering (AE) programs are ABET-accredited in the US. ABET accreditation is an important credential for the US, and is becoming more widely accepted internationally. It is essential to the reputation of a program and is required for students to be allowed to sit for the Fundamentals of Engineering examination which is one of the steps toward professional licensure. To gain accreditation, a program must meet general criteria common to all engineering programs and specific criteria that are unique to the type of program (ABET 2009). The program criteria are written and approved by the professional society that represents an individual program. For the AE programs, the lead society is the American Society of Civil Engineers and the cooperating society is the American Society of Heating, Refrigerating, and Air-Conditioning Engineers.

A subcommittee of Architectural Engineering Institute (AEI) Academic Council rewrote the program criteria for all accredited AE programs. The committee consisted of Jay Puckett (University of Wyoming), Al Estes (Cal Poly), Rich Klingner (University of Texas), Jim Mitchell (Drexel University), John Zachar (Milwaukee School of Engineering), Ray Yunk (Kansas State University) and Clarence Waters (University of Nebraska). The AEI Academic Council formally approved the new criteria at the AEI annual conference in Denver in April

2009. The AEI Board of Governors, the ASCE Committee on Curricula and Accreditation, and the ASCE Committee on Educational Activities have all approved the new criteria. The ABET Engineering Accreditation Commission Criteria Committee and the Engineering Accreditation Commission approved the new criteria in July 2010. The ABET Board of Directors approved the criteria for first reading in October 2010. The new criteria will be published in the “Proposed Changes” section of the *2011-2012 Criteria for Accrediting Engineering Programs* before being formally adopted. The criteria are expected to be in effect for the 2012-2013 accreditation cycle. Meanwhile, the AEI Academic Council has approved a draft commentary that will help to support the new criteria.

This paper examines the new AE program criteria and reports on the issues and decisions that were made to develop 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.

Existing Criteria

The ABET AE program criteria¹ that is currently in effect is listed below:

Current Architectural Engineering ABET Criteria

Curriculum -- The program must demonstrate that graduates have: proficiency in mathematics through differential equations, probability and statistics, calculus-based physics, and general chemistry; proficiency in statics, strength of materials, thermodynamics, fluid mechanics, electric circuits, and engineering economics; proficiency in a minimum of two (2) of the three (3) basic curriculum areas of structures, building mechanical and electrical systems, and construction/construction management; engineering design capabilities in at least two (2) of the three (3) basic curriculum areas of architectural engineering, and that design has been integrated across the breadth of the program; and an understanding of architectural design and history leading to architectural design that will permit communication, and interaction, with the other design professionals in the execution of building projects.

Faculty -- Program faculty must have responsibility and sufficient authority to define, revise, implement, and achieve program objectives. The program must demonstrate that faculty teaching courses that are primarily engineering design in content are qualified to teach the subject matter by virtue of professional licensure, or by education and design experience. It must also demonstrate that the majority of the faculty members teaching architectural design courses are qualified to teach the subject matter by virtue of professional licensure, or by education and design experience.

There were several reasons for revising the program criteria. The ABET general criteria have evolved over the past decade and the program criteria have not been re-examined. Unresolved issues have arisen regarding the prescriptive nature of curriculum requirements, the appropriate emphasis in curricular areas, the definition of proficiency, and the role of architecture. A second major factor is that Civil Engineering program criteria were recently revised to incorporate the CE Body of Knowledge² and use Bloom’s taxonomy³ to more coherently define the cognitive level being achieved. Because the civil engineers conducted a rigorous analysis and made specific decisions on these criteria, this was an opportunity for the architectural engineers to examine their work and update their document.

Civil Engineering Program Criteria

Because the CE and AE programs share the same lead society and, most importantly, many similar professional characteristics, it makes sense for the respective program criteria to be compatible where possible. Considerable overlap exists in the curricula for the two programs, particularly in the areas of structural engineering, construction and generalities of engineering practice. Furthermore, almost half of the AE programs are administratively housed departments with CE and many aspects of the CE and AE programs are shared. This commonality argues for compatible criteria.

Previous Civil Engineering ABET Criteria⁴:

Curriculum --The program must demonstrate that graduates have: proficiency in mathematics through differential equations, probability and statistics, calculus-based physics, and general chemistry; proficiency in a minimum of four (4) recognized major civil engineering areas; the ability to conduct laboratory experiments and to critically analyze and interpret data in more than one of the recognized major civil engineering areas; the ability to perform civil engineering design by means of design experiences integrated throughout the professional component of the curriculum; and an understanding of professional practice issues such as: procurement of work, bidding versus quality-based selection processes, how the design professionals and the construction professions interact to construct a project, the importance of professional licensure and continuing education, and/or other professional practice issues.

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

New Civil Engineering ABET criteria¹:

Curriculum --The program must demonstrate that graduates can: apply knowledge of mathematics through differential equations, calculus-based physics, chemistry, and at least one additional area of science, consistent with the program educational objectives; apply knowledge of four technical areas appropriate to civil engineering; conduct civil engineering experiments and analyze and interpret the resulting data; design a system, component, or process in more than one civil engineering context; explain basic concepts in management, business, public policy, and leadership; and explain the importance of professional licensure.

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

There were some key changes in the new CE program criteria. There was a concerted effort to be less prescriptive and allow programs more freedom to achieve their desired outcomes. Specific references to procurement of work, bidding and the specific requirement for probability and statistics were removed. The requirement for an area of science in addition to physics and chemistry was added. The CE criteria required a level of understanding in the areas of management, business, public policy and leadership...topics that had never appeared before but were deemed important in the CE Body of Knowledge. The level of understanding was quantified using Bloom's taxonomy and verbs such as "explain" were used to define the cognitive level to be attained. The criteria reflect ASCE Policy 465⁵ which argues for a broad undergraduate education and more technical specialization at the master's degree level.

Proposed Architectural Engineering Criteria

After considerable discussion of issues and several revisions, the following criteria were approved by the AEI Academic Council:

New Proposed Architectural Engineering ABET criteria:

Curriculum -- The program must demonstrate that graduates can apply mathematics through differential equations, calculus-based physics, and chemistry. The four basic architectural engineering curriculum areas are building structures, building mechanical systems, building electrical systems, and construction/construction management. Graduates are expected to reach the synthesis (design) level in one of these areas, the application level in a second area, and the comprehension level in the remaining two areas. The engineering topics required by the general criteria shall support the engineering fundamentals of each of these four areas at the specified level. Graduates are expected to discuss the basic concepts of architecture in a context of architectural design and history.

The design level must be in a context that:

- a. Considers the systems or processes from other architectural engineering curricular areas,
- b. Works within the overall architectural design,
- c. Includes communication and collaboration with other design or construction team members,
- d. Includes computer-based technology and considers applicable codes and standards, and
- e. Considers fundamental attributes of building performance and sustainability.

Faculty -- The program must demonstrate that faculty teaching courses that are primarily engineering design in content are qualified to teach the subject matter by virtue of professional licensure, or by education and design experience. It must also demonstrate that the majority of the faculty members teaching architectural design courses are qualified to teach the subject matter by virtue of professional licensure, or by education and design experience.

Key Issues

While the criteria are only a half a page long, there was considerable discussion and a number of key issues that required resolution and some sort of consensus. These included:

- The accreditation document is a minimum standards document. There was a tendency among the group to take an inspirational and visionary approach to what an architectural engineering could be. Because every program would have to meet the criteria to attain accreditation, it was important to set the standard at the appropriate level – high enough to ensure acceptable standards in all programs, but reasonable enough to allow programs the flexibility to choose different paths to excellence.

- The previous criteria required proficiency in two of the three recognized areas of architectural engineering: construction, structures and electrical/mechanical systems. Some asked why the separate areas had to be specifically delineated. Why not allow programs the freedom to pursue any path they desired? It was argued that an AE program that chose fire suppression and acoustics as their two areas might not be acceptable and guidance was needed. The group agreed to divide electrical and mechanical systems because they represent two separate disciplines thus creating four recognized areas of AE. The more deliberative debate was the required level of proficiency in each of these four areas. The 17 accredited programs have different curricular emphases and the goal was to maintain standards but not to impose unreasonable burdens. Estes and Estrada⁶ presented the difference in the various programs which range from the Cal Poly AE program (four year program located in a college of architecture that focuses heavily on structures and neglects electrical/mechanical systems) to the

Penn State AE program (five year program in a college of engineering with an opportunities in all recognized areas) with every possible combination in between.

- Since the group agreed to incorporate Bloom's Taxonomy (Knowledge, Comprehension, Application, Analysis, Synthesis, Evaluation), there was significant debate on the appropriate cognitive level for those various areas. The compromise consensus solution was to require a design/synthesis level capability in one area, application level capability in another area and comprehension level in the remaining two. Programs are welcome to exceed those standards, but these allow programs to specialize in individual areas while permitting a lower cognitive level on some areas. Whether students should be expected to reach the evaluation level was discussed. It was recognized that learning does not stop after the undergraduate education, and that attainment of the true evaluation level often requires the experience gained from an advanced degree, professional practice, or combinations thereof.

- Because each program contains some coverage of architecture, the specified cognitive level of attainment was discussed and the comprehension level was chosen as the minimum, even though many programs will exceed that. As a minimum, AE graduates must be able to explain and describe the role of architecture and the architect in the design of a building. The choice to leave architectural history in the criteria was deliberate. The former criteria forced AE programs to address architectural history. Many felt that the topic was valuable and could be lost if not explicitly included in the criteria.

- The previous criteria contained a prescriptive list of topics that must be addressed in a program. The list essentially required *proficiency* in all of the topics on the Fundamentals of Engineering exam. For many evaluators and programs, that translated into a mandatory course in those subjects. The statement that, "The engineering topics required by the general criteria shall support the engineering fundamentals of each of these four areas at the specified level" is intended to ensure that the removal of the prescriptive list does not lead to the elimination of fundamental engineering science courses. The intent is not to lower the bar, but rather to accommodate the wide range of academic program needs and constraints.

- The explicit requirement for probability and statistics was eliminated for a similar reason. The general criteria requirement for a year of math and basic science for all engineering programs prevents programs from neglecting these critical areas. Similarly, the AE community chose not to add the extra science requirement mandated by the CE criteria. The committee was concerned that programs would be forced to cut an extra semester of physics or chemistry to make room for biology, ecology, geology, or some other area of science that might not best fit their program.

- The committee chose not to implement the CE requirement that a program not be overly dependent on a single individual. Some of the AE programs are small and are one-deep in some areas of AE. Similarly, the CE requirement for leadership, public policy and business policy was not included in the current AE criteria. The general criteria provide sufficient requirement for awareness of contemporary issues and the global, economic and social understanding of engineering.

- The statement that “Program faculty must have responsibility and sufficient authority to define, revise, implement, and achieve program objectives” was removed from the old criteria. The requirement is contained almost verbatim in Criterion 5 (Faculty) of the general criteria and its deletion avoids redundancy.

- The committee went to considerable effort to describe what is included in the design level capability. For example, the design must “consider” the systems or processes from other architectural engineering curricular areas. There was considerable debate as to whether “consider” should be replaced with “integrate” or “include”. For a program that is achieving the design level in the area of structures and the comprehension level in mechanical systems, it seemed appropriate the structural design should only be required to consider the mechanical issues in a structural design. There was some debate that system integration should have more emphasis because that is a major AE function and a focus of the AEI, but it became too difficult given the differences in the various programs.

- The new criteria included sustainability and building performance into the building design. The commentary will need to have some discussion as to the definition of sustainability and building performance since the terms can take different definitions. The criteria also specifically include communication and collaboration with other design and construction team members as well as inclusion of computer-based technology and latest codes into the design. The words computer-based technology and latest codes were deliberately chosen over information technology which is broader and less well defined. Similarly, the selection of “design and construction team members” was deliberately chosen over “other design professionals”, thereby emphasizing the important link to the construction process. Besides, the other members of the team are fellow students who are not yet professionals.

- The committee decided to keep the provision on the education and licensure requirements for those faculty members who teach architecture. The commentary will address that the intent is to protect architecture faculty who teach within an AE department. For those programs which use architecture studios taught by faculty in an Architecture program, the provision is intended to ensure minimum qualifications for those faculty, without dictating specific requirements for faculty members who operate outside the control of the AE program.

Commentary

The ASCE Committee on Curricula and Accreditation developed a Civil Engineering commentary⁷ that provides guidance to both evaluators and programs to clarify and amplify the CE program criteria. The commentary is not an official ABET publication and does not modify either the ABET general or program criteria. The CE commentary is a broader and more comprehensive document than that used by any other society. It is 16 pages long and individually addresses every element of the program criteria and links it to any applicable general criteria requirements. It provides context and detailed explanation and ultimately offer a great deal of both philosophy and perspective comment to every aspect of the accreditation criteria. Bloom’s taxonomy and suggested applications are provided in an appendix.

The AE criteria subcommittee debated whether or not to create a similar overarching philosophical document or a much shorter document that only addressed the most critical elements of the program criteria. The consideration was that a one page document stood a far greater chance of being read. Because the content of the CE commentary was so valuable and addressed so many critical issues, the AE committee opted for a similar AE commentary document and borrowed much of the language from the CE commentary.

Conclusions

The proposed Architectural Engineering program criteria are comprehensive yet less prescriptive than the existing criteria. The process generated detailed thought and fruitful discussion among the 17 existing programs. The criteria represent a developed consensus and in many cases, represent some compromises among disparate programs. The effort was aided considerably by the outstanding groundwork already completed by the civil engineering community, which provided a framework for some of the discussion. The CE community will hopefully benefit from this separate analysis of their work and in some cases, the decisions reached were different. ABET accreditation process is an endeavor involving continuous assessment and improvement, and in which outcomes and objectives are demonstrated relative to program criteria. While some might see ABET as an outside organization that dictates what programs must do, this paper points out the vital role played by architectural engineering programs in establishing the criteria and setting the standards by which they are to be evaluated. This is an important aspect of our engineering accreditation process, which supports a wide range of programs, curricular evolution and development, and also meets the expectations of our profession.

Bibliography

¹ ABET Inc. "Criteria for Accrediting Engineering Programs," Effective for Evaluations During the 2009-2010 Accreditation Cycle, Engineering Accreditation Commission, Accreditation Board for Engineering and Technology, ABET, Inc., Baltimore, Maryland, 2009.

² American Society of Civil Engineers (2004) *Civil Engineering Body of Knowledge for the 21st Century*. Committee on Academic Prerequisites for Professional Practice, American Society of Civil Engineers, Reston, Virginia, ASCE, 2004.

³ Bloom, B.S. (1956) *Taxonomy of educational objectives*, New York: Longman, 1956.

⁴ ABET Inc. (2006). "Criteria for Accrediting Engineering Programs," Effective for Evaluations During the 2006-2007 Accreditation Cycle, Engineering Accreditation Commission, Accreditation Board for Engineering and Technology, ABET, Inc., Baltimore, Maryland, 2006.

⁵ American Society of Civil Engineers (2007a) "Policy Statement 465 - Academic Prerequisites for Licensure and Professional Practice" Adopted by the Board of Direction on April 24, 2007
<http://www.asce.org/Content.aspx?id=26194> accessed 20 September 2010

⁶ Estes, A.C. and Estrada, H. (2008). "The Nation's Architectural Engineering Programs: A Diverse Group" Proceedings of the Architectural Engineering Institute Annual Conference 2008, ASCE, Denver, CO. September 25-27, 2008.

⁷ American Society of Civil Engineers (2008) "Commentary: On the ABET Engineering Criteria for Civil and Similarly Named Programs In the Context of the Civil Engineering Body of Knowledge" 2008.
http://apps.asce.org/pdf/Revised_Civil_Draft_Commentary.pdf accessed January 15, 2011