DRAFT COMMENTARY

Program Criteria for "Architectural" and Similarly Named Engineering Programs
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By the Committee on Accreditation of AE Programs chaired by John Zachar

This document has been prepared by the AEI Academic Council (AAC). The purpose of this document is to provide guidance to architectural engineering program evaluators by clarifying and amplifying the Architectural Engineering Program Criteria used in association with the ABET/EAC criteria for accrediting architectural engineering programs in the United States. Nothing in this document is intended to add to, detract from, or modify the ABET/EAC Criteria for Accrediting Engineering Programs, General or Program Criteria.

The interpretations presented herein reflect the judgment of the originators and reviewers of the document. In the spirit of ABET/EAC Criteria for Accrediting Engineering Programs, there is no single approach to satisfying the requirements of either the general criteria or the program criteria. Rather, the educational institutions are encouraged to innovate within the overall guiding concept of an outcomes based assessment process.

The professional practice of architectural engineering is broad and diverse. As a result, the professional component of architectural engineering education must necessarily be broad. This precept is recognized by AAC and has been adhered to in the development of the program criteria and this Commentary.

The ABET/EAC program evaluators and the respective program chairs/heads are encouraged to utilize this document as a resource and guidance document, and not as a textbook to be followed blindly. It is expected that utilization of this Commentary will stimulate a healthy discussion between the program evaluator and the chair/head of the program being evaluated.

ARCHITECTURAL ENGINEERING 2007-2008 PROGRAM CRITERIA:

These program criteria apply to engineering programs including "architectural" and similar modifiers in their titles.

1. 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.

2. 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 teaching architectural design courses are qualified to teach the subject matter by virtue of professional licensure, or by education and design experience.

EXPLANATION OF THE USE OF THE TERM "PROFICIENCY"

The term "proficiency" is used in the Curriculum portion of the Program Criteria several times. Proficiency has many dictionary meanings varying from novice to expert. Proficiency, as defined by academic standards of universities, colleges of engineering, and departments, generally means satisfactory progress towards meeting the requirements for a degree and graduation. Therefore, proficiency in a subject matter can be viewed as strictly the purview of the university and the academic units. However, the authors of the Program Criteria have used proficiency to be a measure of their expectations of the basic architectural engineering knowledge imparted to the graduating architectural engineer student.

The requirement for “proficiency” in some subjects can be met by taking at least one class in each of those areas and performing at an acceptable level on specified tasks (homework, labs, exams, presentations etc.). Classes such as statics, mechanics of materials, thermodynamics, fluid mechanics, and electrical circuits are typically called “engineering sciences” and a typical AE program will offer one class in each of these subjects. The knowledge learned in the prerequisite math and science classes will be applied in these and subsequent engineering classes, which is also a way to demonstrate proficiency. Engineering economics, while not usually considered an engineering science, is also included as part of a typical AE curriculum and an important part of the building design practice.

The core areas of Architectural Engineering include Building Structural Systems, Building Mechanical and Electrical Systems, and Construction/Construction Management. For purpose of this commentary these will be referred to as specialty areas and every AE program will have classes that address them to some degree. As in all professions, a broad educational background is important but specialized knowledge is normally the prerequisite for a career. Therefore, each of those basic specialty areas can be divided into multiple sub specialty areas. For example, "Building Structural Systems" can include classes in structural analysis, reinforced concrete design, soil mechanics, foundation design, steel design, timber design, masonry design and others. "Building Mechanical Systems" may include courses in the design of heating systems, cooling systems, plumbing systems, fire suppression systems and others. "Building Electrical Systems" may include courses in power distribution, power quality, communications and controls systems design, illumination design, acoustics and others. Construction/Construction Management can include courses in contracts and specifications, project management, estimating, scheduling, and others. It would not be unusual for an AE graduate to have a career in one of the sub specialty areas, and in fact it would be difficult for any one engineer to have complete competency in all aspects of a specific area.

Some AE programs direct their students into a particular specialty area; other programs allow their students to choose a specialty area themselves. In either case, an AE graduate will typically have taken many extra sub specialty classes in order to be a competent design professional.

Demonstration of proficiency implies an ability to accomplish something, such as design of a building system under certain constraints or the application of statistics to the analysis of experimental data. For example, a demonstration of proficiency in mechanical systems could be the design of a building heating, ventilation and air-conditioning system by applying knowledge of the concepts of thermodynamics, fluid mechanics, and heat transfer and considering physical, legal,

economic, and environmental factors. Proficiency in construction / construction management could include creating an accurate estimate and a competitive bid based on a set of plans or being able design a workable and accurate schedule.

Nothing in the AE criteria should be construed to preclude design specialization in a specific area. Nothing in the criteria should be construed to dictate the method by which a curriculum gets a student to take the classes required, nor in any way does it prohibit a University from offering classes that combine different specialty topics. It is the right of the individual University to design their curriculum to meet the needs set forth by faculty, employers, industrial advisory boards, and other stakeholders.

EXPLANATION OF THE TERM "ENGINEERING DESIGN"

Engineering design is a process of analysis and synthesis. Analysis that is not followed by synthesis is not engineering design. In most junior and senior analysis courses the distinction between engineering science and design is blurred. Analysis is the prelude to design. Engineering design is the directed synthesis of known facts brought together for a purposeful and successful end. Design is the process of solving, not just identifying problems. By this definition, there are many "right" answers to a design problem. The hallmarks of engineering design content in coursework are problem and constraint identification, analysis, and synthesis towards an identifiable end.

However, design is not necessarily a set of plans and specifications to construct a building or a portion of a building. It entails conceptualizing, testing, and proving the solution to a problem. This definition of design should be applied to all design elements of any architectural engineering curriculum.

Note that this definition of design does not require the devising of a complete system in all cases. The design of a subsystem of a larger system also is included under the definition of design. The development of a process to solve a problem is also included under design.

Is there a statement of desired needs, and is there a process for devising a method to satisfy those needs? This process is the critical element in determining whether something is or is not design.

Engineering design is also a decision-making process and often, but not always, is an iterative process. Thus, using only the concept of an iterative process to judge design is too restrictive. Some engineering design may not explicitly include an iterative approach between conceptualization of a solution and the analysis of that solution to determine whether all applicable constraints have been met. While this would be ideal, the ABET criteria recognize that requiring all engineering design elements of a curriculum to be truly iterative would place a very heavy burden on both faculty and students. Possibly with the increased utilization of computer software to speed the analysis element of the design process, there will be an increased emphasis on the iterative process, but currently there is no ABET requirement that all design consist of an iterative process.

The evaluator must realize that the time constraints on the faculty and students require that most often the design problem must be constrained so that the correct results will lie within a narrow range of solutions.

Engineering design includes both analysis and synthesis. The more that engineering standards and realistic constraints of design are incorporated into a specific engineering design problem, the more instructive that problem will be.

In addition, the course outline, handouts or course syllabus should show that various standards and constraints of design are included in the course and should indicate just where these elements are placed in the normal progression of the course work.

While many evaluators look for open-ended problems as a sign of engineering design, open-endedness is only one characteristic of design and does not have to be present in each design assignment. Not all open-ended problems qualify as engineering design because some may be so open-ended that the students cannot begin to determine appropriate solutions. The evaluator must remember that the students are not experienced engineers tempered by years of professional practice. Open-ended problems that are presented to students must certainly be constrained by the student's level of knowledge and experience.

The design experience should be taught in such a manner that there is sufficient interaction among students on the design team and the instructor such that the students perceive design as a decision-making process, often iterative, with no clear-cut single solution. Design teams should be multi-disciplinary (addresses Criterion 3 (d)). In architectural engineering design, a multi-disciplinary team normally includes students with expertise in the different areas of architectural engineering. It may also include individuals from other engineering and/or non-engineering disciplines. The constraints of other programs obviously limit the extent to which non architectural engineering students may participate on AE design teams.

The major design experience should be clearly identified in the curriculum and examples provided of the design projects. The faculty and upper level students should be cognizant of the design experience and its importance to the curriculum. The design experience should focus attention on professional practice in both technical and non-technical issues. The experience should be as broad as possible but does not necessarily have to encompass all of the architectural engineering areas of practice.

While design in the sub-disciplines of structural, mechanical and electrical systems is reasonably easy to quantify, design in construction is less clearly defined. Construction design can obviously include the design of shoring, form work and scaffolding. It can also mean designing structural connections, HVAC duct routing, or electrical circuiting for constructability purposes. Construction design can also include creating an estimate, a construction schedule or a quality control plan. In general, design consists of creating something that does currently exist. AE programs must be given latitude in how they define it.

PROGRAM CRITERIA

"1. Curriculum"

“The program must demonstrate that the graduates have:”

"proficiency in mathematics through differential equations; probability and statistics; calculus-based physics; and general chemistry."

This criterion amplifies the requirements of Criterion 4, "Professional Component" of the general criteria.

The general criteria require one year of "college level mathematics and basic sciences". There is no specific requirement for a minimum number of class hours in any of the topics mentioned in the program criterion; therefore, each program is free to be innovative as long as the mission is fulfilled and the program objectives are met. The Program Evaluator must be careful not to require a prescriptive set of courses to meet the one-year requirement of the general criteria. In fact, in some innovative programs there may be combined courses in calculus and physics taught on a "just in time" basis. It will be important to keep an open mind and evaluate the outcome of the processes employed.

It is likely that the programs being evaluated will require the assistance of the departments that are responsible for the math and science courses in order to demonstrate proficiency. Further, these support departments will have to be aware of the "proficiency" requirements in the accreditation process.

“The program must demonstrate that graduates have:”

"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;

As mentioned previously, the field of architectural engineering consists of several interrelated systems involving structural systems, electrical systems, mechanical systems and construction. Multidisciplinary design teams may include representatives of any and all of these fields and their multiple sub specialties. Any major architectural construction project involves most, if not all of these areas. The areas of structures, building mechanical / electrical systems, and construction are generally considered the cornerstones of architectural engineering and thus all architectural engineering students should be proficient in at least two of these important areas.

A major problem with interpretation of this criterion relates to the listing of building mechanical and electrical systems as a single area for proficiency. In keeping with the spirit of the Criteria for Accrediting Engineering Programs, all programs should have flexibility in meeting this requirement and may choose to emphasize either mechanical or electrical systems or both.

“The program must demonstrate that the graduates have:”

“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;”

This program criterion amplifies Criterion 3(c) that states "*Engineering programs must demonstrate that their graduates have an ability to design a system, component, or process to meet desired needs.*"

Demonstration of "*...engineering design capabilities...*" indicates production of a reviewable product which has incorporated "design" principles where a system or a component has been devised to meet a desired need. The reviewable satisfactory product of the "major design experience" discussed in Criterion 4 of the general criteria may fulfill the demonstration needed for ability to perform architectural engineering design.

The program criterion requires that the "*design experiences (be) integrated throughout the professional component of the curriculum*." Although not the intent, the general criteria would seemingly permit all of the design in a program to be resident in the "major design experience" of Criterion 4.

The AAC believes it is preferable to integrate the learning of the design process throughout the professional component of the curriculum, and then to culminate in a major design experience which draws upon and pulls together that which has been learned in previous classes.

The professional component of the curriculum is defined by AAC as primarily the engineering design classes (rather than engineering science) taught by architectural engineering faculty, or engineering faculty from other engineering disciplines. It is unlikely that engineering design will be taught by faculty from mathematics, basic sciences, humanities or social sciences. Since many programs enroll transfer students into the third year of the curriculum, the professional component may be considered as courses from the upper division years of the curriculum.

The AAC also wants to note that ABET Criterion 3(b) states that "Engineering programs must demonstrate that their students attain: (b) an ability to design and conduct experiments…" Architectural engineering students typically do not design experiments in the traditional sense. Many AE related experiments are based on fixed standards such as those set by ASTM. Evaluators are encouraged to allow flexibility in how programs interpret and implement this requirement.

"The program must demonstrate that the graduates have:"

" 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."

This program criterion is an amplification of Criterion 3(f) from the general criteria. Criterion 3(f) states that "*Engineering programs must demonstrate that their graduates have an understanding of professional and ethical responsibility*." Architectural engineers may be unique in that their profession requires a very close interaction with another professional discipline, namely architecture, throughout the life of a project. The AAC believes it is a professional responsibility for architectural engineers to have a basic understanding of the design process of the architects involved in the execution of building projects.

This criterion is the only architectural engineering program criterion that states the *"Graduates of the program must have understanding*..." versus demonstrating a proficiency or ability. Demonstration of an understanding is a different type of proof than demonstrating proficiency. Demonstration of proficiency implies an ability to accomplish something, such as design of a reinforced concrete beam under certain constraints. Demonstration of an understanding of a subject implies exposure to the subject and assimilation of the important aspects of the concept. The graduates are not expected to become proficient in architectural design. As such, a single course in the history of Architecture typically provides sufficient understanding of terminology and philosophy to permit communication and interaction with the architectural design professionals.

PROGRAM CRITERIA

"2. Faculty"

> ***"The program must demonstrate that faculty teaching courses that are primarily design in content are qualified to teach the subject matter by virtue of professional licensure, or by education and design experience.***

Common to both the general and program criteria is the wording "*The program must demonstrate...*". There are innumerable methods available to demonstrate the various facets of the general and program criteria. The role of the program evaluator is to make the judgment as to whether the submitted material adequately demonstrates what is claimed.

The phrase "*... courses that are primarily design in content...*" is intended to apply to the differentiation between engineering science and engineering design courses. Courses in this category would be those, typically in the third and fourth years, where design is a majority percentage of the course.

The faculty teaching courses that contain a minority percentage of design in the overall course are not addressed in the program criteria.

As an aid to the Program Evaluator in differentiating which classes and faculty are covered by this criterion, the program may elect to include a tabulation that indicates the design component of each class, and the faculty who teach the respective courses.

The next phrase, "*...are qualified to teach the subject matter by virtue of professional licensure, or by education and design experience*." describes the minimal ABET/EAC qualifications necessary to teach the design courses. The program must demonstrate to the reasonable satisfaction of the program evaluator that the affected faculty members meet one or the other of these qualifications.

Professional licensure, usually as a Professional Engineer (P.E.), is considered satisfactory evidence of necessary qualifications to teach engineering design. However, there are other factors that also should be considered, including, is the licensure current and granted by the jurisdiction where the faculty member is teaching? Is licensure outside of the United States or in something other than engineering, or architectural engineering, adequate? Some jurisdictions explicitly consider the teaching of design courses, or advanced engineering courses in general, as the practice of engineering. Therefore, engineering faculty in those jurisdictions may have a legal obligation for professional licensure, which is beyond the scope of the ABET/EAC accreditation evaluation.

The demonstration by the program that the relevant faculty members are qualified by virtue of professional licensure can be as simple as a table with the appropriate information. Information to be included in the table could include state or jurisdiction of licensure, discipline of licensure (if appropriate), date of initial licensure, and the expiration date of the license.

Professional licensure may either be in architecture or a relevant engineering discipline. In many AE programs, the Architecture faculty are formally part of other departments, and because of this, the AE program has less control over qualifications. Licensure in a discipline closely related to the field in which the faculty member is teaching design may constitute relevant licensure and may be sufficient for satisfying this requirement. For example, licensure as a professional geologist along with appropriate design experience may be sufficient to satisfy the overall requirement to teach a design course like “Soil mechanics and Foundations”.

Certifications are available in many disciplines and specialties. Certifications are not licensure and cannot be used to fully satisfy this requirement. However, certification may be an indication of faculty proficiency or expertise in a particular field. Thus, certification may be helpful in demonstrating experience in a specific discipline or specialty.

The second half of the requirement "...*or by education and design experience*." is the Academic Councils means for providing an alternative to the demonstration by licensure that a faculty member is qualified to teach design in a specific area. It is recognized by inclusion of this phrase that the appropriate qualifications to teach design in an architectural engineering program may not be solely defined by professional licensure.

The education of a person claiming competency under this phrase probably will be in a field closely related to that in which they are teaching design. For instance, the related field may be electrical or mechanical engineering. Of equal or greater importance than the specifics of their education is what the individual has accomplished since obtaining the related education.

The specifics of claimed experience in design should be concisely documented by the claimant and the program. Design experience can come in many forms and from many types of employment. The most common may be industrial experience working for the private sector. Design experience may come in a sustained period of employment, or it may come incrementally over a several year period. Generally, design experience that is repetitious in nature, such as repeatedly designing the same component or type of facility, usually does not provide credit toward licensure beyond the initial performance. The specific method for documenting the claimed design experience is left to the program. There is no one correct answer.