

# AMERICAN SOCIETY OF CIVIL ENGINEERS

## COMMENTARY

### For Architectural Engineering Programs

Draft of September 2010

#### Purpose

This document has been prepared by the ASCE Committee on Curriculum and Accreditation (CC&A). The purpose of this document is to provide guidance to architectural engineering program evaluators by clarifying and amplifying the Architectural Engineering (ArE) Program Criteria to be utilized in association with the ABET/EAC Criteria for Accrediting Engineering Programs. Nothing in this Commentary is intended to add to, detract from, or modify the ABET/EAC Criteria. Although this document is written for program evaluators, others may find it useful in reviewing their own programs for consistency with the Architectural Engineering Program Criteria contained in the ABET/EAC Criteria.

Program evaluation is an inherently subjective process. This Commentary is intended to help evaluators make subjective judgments in a manner that is consistent with the ABET/EAC Criteria. Evaluators are encouraged to use this document as a resource for the decision-making process, not as a set of rigid rules to be followed without some flexibility. Ultimately, decisions about compliance with the criteria must be based principally on the evaluator's professional judgment—informed by the Team Chair's guidance and appropriate program documentation.

Throughout this commentary references are made to Bloom's Taxonomy. Bloom's Taxonomy is not a part of the Architectural Engineering Program Criteria. However, the authors of the criteria consulted Bloom's Taxonomy in selecting the verbs used to describe intended *levels of achievement*. Consequently, references to the taxonomy are made to provide guidance in interpreting the language used. A brief discussion of the taxonomy is contained as an appendix to this document.

The information presented in this Commentary reflects the best collective judgment of its authors and reviewers. It is subject to continual review and revision, reflecting input from constituencies and lessons learned from accreditation practice.

#### Organization and Contents

This Commentary is organized in terms of the requirements prescribed by the **Architectural Engineering Program Curriculum Criteria**. Each section includes a discussion followed by suggestions for ways compliance might be demonstrated.

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## ABET/EAC Criterion 3. Program Outcomes

Engineering programs must demonstrate that their students attain the following outcomes:

- (a) an ability to apply knowledge of mathematics, science, and engineering
- (b) an ability to design and conduct experiments, as well as to analyze and interpret data
- (c) 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
- (d) an ability to function on multidisciplinary teams
- (e) an ability to identify, formulate, and solve engineering problems
- (f) an understanding of professional and ethical responsibility
- (g) an ability to communicate effectively
- (h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
- (i) a recognition of the need for, and an ability to engage in life-long learning
- (j) a knowledge of contemporary issues
- (k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

## ABET/EAC Criterion 9. Program Criteria for Architectural Engineering Programs

The program must prepare graduates to 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 be able 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.

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## Knowledge of Mathematics & Science

### Architectural Engineering Program Criteria

This section states the related portion of the Architectural Engineering Program Criteria:

The program must prepare graduates to apply mathematics through differential equations, calculus-based physics, and chemistry.

### Related General Criterion 3(a)

This portion of the Architectural Engineering Program Criteria must be considered in relation to the following outcome prescribed in the General Criteria:

Engineering programs must demonstrate that their graduates have...an ability to apply knowledge of mathematics, science, and engineering.

### Discussion

Mathematics through differential equations, calculus-based physics, and chemistry are considered to be part of the *technical core* of architectural engineering and thus are explicitly required by the ArE Program Criteria. Although not explicitly required, probability and statistics concepts are integral to most architectural engineering subjects, and therefore, students should have an appropriate opportunity to acquire the mathematical prerequisites. Moreover, graduates are required to be able to analyze and interpret data from experiments which implies some background in probability and statistics. It would be entirely feasible for such opportunities to occur in the associated engineering courses, rather than in a specific course in probability and statistics.

Consistent with Bloom's Taxonomy (see appendix), the verb "apply" in this provision of the Program Criteria implies that the expected level of achievement is Level 3, Application. To comply with this criterion, the program must demonstrate that its graduates can apply concepts and principles from math and science to solve relatively straightforward problems.

There is no requirement for a minimum number of credit hours or courses in any of these subject areas. The evaluation should be based principally on graduates' demonstrated ability to solve problems, not on curricular content.

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## Suggestions for Demonstrating Compliance

A variety of measures can be used to demonstrate graduates' ability to apply knowledge of math and science. Some possible measures include:

- Documented assessment of students' math and science problem-solving work.
- Documented successful application of the specified math and science topics in subsequent engineering courses.
- Performance on math and science questions on nationally normed tests, such as the Fundamentals of Engineering Exam or the Graduate Record Examination.

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## Conduct Architectural Engineering Experiments

### Architectural Engineering Program Criteria

This section discusses the following portion of the Architectural Engineering Program Criteria, in the context of General Criterion 3(b):

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 be able 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.

### Related General Criterion 3(b)

This portion of the Architectural Engineering Program Criteria must be considered in relation to the following outcome prescribed in the General Criteria:

- b. Engineering programs must demonstrate that their graduates have...an ability to design and conduct experiments, as well as to analyze and interpret data.

### Discussion

Although Criterion 3(b) is not addressed explicitly in the Architectural Engineering Program Criteria, it is addressed implicitly, except for the requirement for an ability to *design experiments*. The design of experiments is not included in the Program Criteria, because architectural engineers generally do not develop experimental procedures; rather, they conduct laboratory experiments according to published standards, such as the American Society for Testing and Materials (ASTM) specifications. Nonetheless, it is important to recognize that the absence of any reference to experimental design in the Architectural Engineering Program Criteria does not relieve a program of responsibility for compliance with the experimental design provision of General Criterion 3(b).

Consistent with Bloom's Taxonomy (see appendix), the verb "design" in this criterion implies that the expected level of achievement is Level 5, Synthesis. Thus the experimental design must reflect the putting together of parts to form a new whole.

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In an architectural engineering context, this level of achievement can be demonstrated through laboratory experiences that are consistent with the standards-based testing used in the architectural engineering profession. For example, a program might require students to design a quality control testing program for some aspect of a construction project, *through the selection and application of appropriate published standards*. Thus, for example, the experimental design might involve determining the type and frequency of ASTM tests to be performed on fresh and hardened concrete during the construction of a building. The student-designed experiment does not necessarily have to be implemented, as long as students have opportunities to conduct experiments elsewhere in the curriculum. Experiments may also be defined in a broader context such as designing and implementing a study in the field for a senior-level design course. While such activities may not be in a laboratory per se, they are certainly consistent with the spirit of the criteria.

However, because the requirement for experimental design occurs only in the General Criteria, there is no requirement for students to design experiments in an architectural engineering context. Thus the program would be in full compliance if students' ability to design experiments were acquired, for example, in a physics, chemistry, or engineering mechanics course.

The emphasis of this provision is on *conducting* laboratory experiments or tests *in an architectural engineering context* and then analyzing, interpreting, and applying the data. Compliance should be demonstrated through graduates' successful completion of laboratory experiences that are characterized by many of the following elements and are documented in written laboratory reports:

- Formulation of the objectives for an experiment/test.
- Organization and documentation of procedure(s).
- Implementation of experimental setup, measurement, and data collection.
- Observation and documentation of error and uncertainties in data collection procedures.
- Critical analysis of data.
- Interpretation of the experimental results with appropriate conclusions and recommendations.
- Application of the experimental results to a real-world architectural engineering problem or situation.

Consistent with Bloom's Taxonomy (see appendix), the verb "conduct" in this provision of the Program Criteria implies that the level of achievement for such tasks as experimental setup, measurement, and data collection is Level 3, Application. The verbs "analyze" and "interpret" imply that the level of achievement for processing experimental data is Level 4, Analysis.

A growing trend in engineering curriculum development involves the use of "virtual laboratories"—computer simulations that attempt to replicate the hands-on experiences of conventional physical labs. In general, such curricular innovations are encouraged, and the program evaluator must keep an open mind when considering their effectiveness. An evaluation of a virtual laboratory experience should consider such factors as:

- Extent to which the subject matter lends itself to accurate simulation.
- Extent to which the simulation replicates the actual physical experiences of setup, measurement, and data collection.
- Nature of student interaction with the simulation.

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- Students' abilities acquired through the simulation.
- Students' satisfaction with their abilities gained through the simulation.

### Suggestions for Demonstrating Compliance

A variety of measures can be used to demonstrate graduates' ability to design and conduct laboratory experiments and to analyze and interpret data. Some possible measures include:

- Documented assessment of student laboratory reports.
- Documented assessment of student projects involving the design of experiments.
- Documented student performance on research projects that have an experimental component.
- Employers' assessment of recent graduates' performance in laboratory work or quality control testing.

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## Design a System, Component, or Process

### Definition of Design

The ABET definition of engineering design is as follows:

Engineering design is the process of devising a system, component, or process to meet desired needs. It is a decision-making process (often iterative), in which the basic sciences, mathematics, and the engineering sciences are applied to convert resources optimally to meet these stated needs.

This definition should form the basis for evaluation of Criterion 3(c), Criterion 4, and the design-related provisions of the Architectural Engineering Program Criteria.

### Architectural Engineering Program Criteria

The majority of the Architectural Engineering Program Criteria pertains to this outcome:

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 be able 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.

### Related General Criterion 3(c)

This portion of the Architectural Engineering Program Criteria must be considered in relation to the following outcome prescribed in the General Criteria:

Engineering programs must demonstrate that their graduates have...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.



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## Discussion

Consistent with Bloom's Taxonomy (see appendix), the verb "design" in this criterion implies that the expected level of achievement is Level 5, Synthesis. Evaluation of graduates' ability to design should take into account the following considerations:

- The engineering design process typically includes both analysis and synthesis. Analysis involves the application of engineering tools and principles to predict the performance of a system, component, or process; synthesis involves the creation of a new system, component or process to meet desired needs. Analysis without synthesis is *not* engineering design.
- Normally, analysis and synthesis are performed in an iterative cycle. Thus students should experience *some* iterative design in the curriculum. It is not necessary for *all* design experiences to be iterative, however.
- Engineering design problems are generally ill defined. As part of their design experience, students should have an opportunity to define a problem, to include determining the problem scope and design objectives.
- Engineering design problems are generally open ended. They have no single correct answer, but rather a range of possible solutions. Nonetheless, the evaluator must recognize that, in an academic setting, there are significant practical constraints on a program's ability to implement truly open-ended design experiences across the curriculum. The program must strike an appropriate balance between the desirability of open-ended design problems, the limitations of students' knowledge and experience, and the need to provide students with high-quality feedback on their designs. It is both typical and appropriate for a design problem to have a relatively narrow range of "correct" solutions.
- Engineering design does not necessarily involve the devising of a complete system. The design of a component (e.g., a beam or column) or subsystem (e.g., a roof truss) constitutes an acceptable design experience. Students' design experience is enhanced, however, if they can also gain an appreciation for the design of large-scale systems.
- Engineering standards and realistic constraints are critical in architectural engineering design. The program must clearly demonstrate where standards and constraints are taught and how they are integrated into the design component of the curriculum. In architectural engineering, the most common types of standards are codes and regulations. Constraints explicitly cited in Criterion 3(c) are economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability considerations. In a architectural engineering context, *manufacturability* is generally interpreted as *constructability*.

One possible source of information that can be considered when evaluating compliance with this criterion is Table I-1 (Basic-Level Curriculum) of the program self-study. In this table, courses containing "significant design" are annotated with an "X".

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## Suggestions for Demonstrating Compliance

The program can use a variety of measures to demonstrate its graduates' ability to perform architectural engineering design. Some possible measures include:

- Documented assessment of student design projects.
- External assessments of student design reports or presentations, performed by clients, advisory board members, etc.
- Employers' assessment of recent graduates' design ability.

Note that merely providing samples of student design project reports would not, by itself, demonstrate students' ability to design a system, component, or process. The program must have assessed the student work (or must have arranged for an external assessment of the student work) and must present evidence that all students, by the time of graduation, have demonstrated this ability at an appropriate standard of performance.

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## Formulate and Solve Problems

### Architectural Engineering Program Criteria

This section discusses the following portion of the Architectural Engineering Program Criteria:

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.

### Related General Criterion 3(e)

This portion of the Architectural Engineering Program Criteria must be considered in relation to the following outcome prescribed in the General Criteria:

Engineering programs must demonstrate that their graduates have...an ability to identify, formulate, and solve engineering problems.

### Discussion

Consistent with Bloom's Taxonomy, the verbs "identify" and "formulate" in this criterion imply that the expected level of achievement is Level 4, Analysis. To comply with this criterion, the program must demonstrate that each graduate can successfully perform engineering analysis by breaking down a system or process into its component parts, such that its performance can be understood.

It should be noted that the Criterion 3(c) requirement for "an ability to design a system, component, or process" specifies Level 5 problem-solving ability. Because analysis is integral to engineering design, it would be entirely permissible for the program to use assessments of students' design work as the basis for demonstrating compliance with *both* Criteria 3(c) and 3(e).

Consistent with Bloom's Taxonomy, the application verbs (such as "calculate," "implement," "relate," "solve," and "use") indicate that the program must demonstrate that each graduate can successfully apply knowledge in an area *other* than the one selected for the synthesis (design) level. Also consistent with the Taxonomy, the comprehension verbs (such as "discuss," "explain," "summarize," and "estimate") indicate that the program must demonstrate that each graduate can successfully converse and related to colleagues in other ArE sub disciplinary areas. Through this provision, ASCE ensures that every architectural engineering graduate has sufficient relevant technical breadth to be considered an architectural engineer and the breadth necessary to work in comprehensive teams.

It is entirely permissible, however, for programs to develop their graduates' technical breadth through coursework in other subject areas. The field of architectural engineering is evolving, and new specialty areas are continually emerging. It is critically important that the enforcement of this criterion not stifle curricular innovation. Nonetheless, a program's four technical areas must include the subjects listed above, with the required levels of achievement.

There is no requirement for a minimum number of credit hours or courses in each of the four technical areas, and there is no requirement that all graduates of a given program take courses in

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the same four areas. The evaluation should be based principally on individual graduates' ability to solve straightforward problems in each area (i.e., to apply knowledge), not on curricular content.

### Suggestions for Demonstrating Compliance

Some possible measures that the program might use to demonstrate graduates' ability to apply knowledge in four architectural engineering technical areas include:

- Documented assessment of student problem-solving work in the four ArE technical areas.
- Successful completion of a course devoted specifically to a given ArE technical area provided the course requires the demonstration of substantive problem solving in the technical area that goes beyond that required in a broad introductory course.
- Successful application of concepts from a given ArE technical area in the subsequent major design experience.
- Performance on the -specific portions of the Fundamentals of Engineering Exam applicable to the ArE technical areas.
- Employers' assessment of recent graduates' performance in the specified ArE technical areas.

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Function in Teams, Communicate, Broad Education, Knowledge of Contemporary Issues, Tools, and Techniques

## Architectural Engineering Program Criteria

This section discusses the following portion of the Architectural Engineering Program Criteria:

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 be able 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.

## Related General Criteria 3(d, g, h, j, and k)

This portion of the Architectural Engineering Program Criteria must be considered in relation to the following outcome prescribed in the General Criteria:

Engineering programs must demonstrate ...

- d. an ability to function on multidisciplinary teams
- g. an ability to communicate effectively
- h. the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
- j. a knowledge of contemporary issues
- k. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

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## Discussion

ArE is a broad and inherently interdisciplinary field. Building design, construction, and operations typically involve architects joined by engineers with skills from the four areas of outlined in the ArE criteria. The ArE Criteria require depth in one area and breadth in others. This duality is necessary to ensure the general knowledge and skills necessary to collaborate with others on the design/construction team. Furthermore, a comprehension level of architectural history and design is complementary. The synthesis level includes teamwork and communications necessary to convey design intent with team member and others. This level includes sustainability which includes economic, societal, and environmental considerations. Contemporary engineering tools, modeling techniques, and specifications will be employed. Tools may include design specifications, building information modeling, structural analysis and design software, building energy modeling and so forth. The specific implementation of the above may vary widely from program to program depending on history, resources, and local needs.

*Building performance* is an important element within ArE, and may be defined using the Energy Independence and Security Act of 2007/Title IV definition for high-performance building<sup>1</sup>

*The term 'high-performance building' means a building that integrates and optimizes on a life cycle basis all major high performance attributes, including energy conservation, environment, safety, security, durability, accessibility, cost-benefit, productivity, sustainability, functionality, and operational considerations.*

Although all of these attributes are important, it is not necessary to include all of them in the synthesis experience or elsewhere in the program. The scope is broad. Programs may select the areas of emphasis and document those outcomes. Again, specific implementation will vary depending upon expertise, resources, and program priorities.

Communications are broad and will typically include oral, written, graphical, and data communications. Programs may document outcomes at various levels throughout the curriculum, e.g., entry level activities to upper level design classes that include presentations, reports, and plans and specifications.

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<sup>1</sup> Energy Independence and Security Act of 2007/Title IV --  
[http://en.wikisource.org/wiki/Energy\\_Independence\\_and\\_Security\\_Act\\_of\\_2007/Title\\_IV#TITLE\\_IV.E2.80.94\\_ENERGY\\_SAVINGS\\_IN\\_BUILDINGS\\_AND\\_INDUSTRY](http://en.wikisource.org/wiki/Energy_Independence_and_Security_Act_of_2007/Title_IV#TITLE_IV.E2.80.94_ENERGY_SAVINGS_IN_BUILDINGS_AND_INDUSTRY)

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## Suggestions for Demonstrating Compliance

The program can use a variety of measures to demonstrate its graduates' ability to work in teams, communicate, and incorporate sustainability and other attributes of building performance knowledge of contemporary issues, and a broad education. Some possible measures include:

- Documented assessment of student design projects.
- External assessments of student design reports or presentations, performed by clients, advisory board members, etc.
- Employers' assessment of recent graduates' design ability.
- Employers' assessment of recent graduates' communication ability.
- Documented assessment of student oral and written communications throughout the curriculum, e.g., portfolio analysis.
- Documented evidence of student broadening experiences and experiences with contemporary issues

## Engineering Fundamentals

### Architectural Engineering Program Criteria

This section discusses the following portion of the Architectural Engineering Program Criteria:

The engineering topics required by the general criteria shall support the engineering fundamentals of each of these four areas at the specified level.

This statement is included to reinforce the need for fundamental engineering theory not just technology in each of the four areas of Architectural Engineering. Evidence might include subject coverage in the areas of statics, mechanics and analysis for building structures; thermodynamics, fluid mechanics, and heat transfer for building mechanical systems; circuits and three-phase power for building electrical systems, and engineering economics and management for construction/construction management, all at the appropriate synthesis, application, or comprehension level.

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## Faculty Requirements

### Architectural Engineering Program Criteria

This section discusses the following portion of the Architectural Engineering Program Criteria:

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..

Common to both the general and program criteria is the wording "*The program must demonstrate...*". The burden for this demonstration is on the program, not the program evaluator. 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. or S.E.), but sometimes as a registered Architect, 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 civil 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.

In general, it is the opinion of CC&A that relevant professional licensure, wherever granted, is satisfactory evidence of fulfillment of this requirement. The legal ramifications of inappropriate or non-existent licensure (practicing engineering without a license) are beyond the scope of the program criteria and this commentary.



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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.

Relevant professional licensure may be in a major architectural engineering discipline, such as architecture or structural engineering.

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 proficiency or expertise in a particular field. Thus, certification may be helpful in demonstrating experience in a specific discipline or specialty, e.g., LEED AP.

*In some programs, the architecture courses are taught by architecture faculty residing in a department of architecture. It needs to be recognized that an architectural engineering program may have little control over the qualifications of faculty members in a different department. A major purpose for this provision is to ensure the minimum qualifications of architecture faculty teaching within an architectural engineering department.*

The second half of the requirement "...or by education and design experience." is CC&A's 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 civil engineering, mechanical engineering, electrical engineering, or architecture. 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.

The program evaluator must also review the class materials to assist in determining if the instructor is qualified to teach the subject matter. This assessment might be especially appropriate for lower level courses with introductory design content.

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## APPENDIX – Bloom’s Taxonomy

*Bloom, Benjamin S. Taxonomy of educational objectives: Cognitive domain. New York: David McKay and Company. 1956*

Bloom’s Taxonomy is a well-established framework for defining educational objectives in terms of the desired level of cognitive development. Bloom’s six levels of cognitive development—*knowledge, comprehension, application, analysis, synthesis, and evaluation*—describe a hierarchy of increasing complexity and sophistication in thought. Definitions of the six levels are provided in the center column of Table 1 below.

The fundamental premise of Bloom’s Taxonomy is that an educational objective can be referenced to a specific level of cognitive development through the *verb* used in the objective statement. Some illustrative examples of verbs associated with Bloom’s six levels are provided in the right-hand column of Table 2.

**Table 1. Bloom's Taxonomy -- Levels of Cognitive Development and Illustrative Verbs**

| Level            | Definition   | Illustrative Verbs  |
|------------------|--|---|
| 1. Knowledge     | the remembering of previously learned material; it may involve the recall of a wide range of material from specific facts to complete theories, but all that is required is the bringing to mind of the appropriate information.   | define; describe; enumerate; identify; label; list; match; name; reproduce; select; state.  |
| 2. Comprehension | the ability to grasp the meaning of material; may be shown by translating material from one form to another (words to numbers), by interpreting material (explaining or summarizing), and by estimating future trends (predicting consequences or effects); this goes one step beyond the simple remembering of material, and represent the lowest level of understanding.   | classify; cite; convert; describe; discuss; estimate; explain; generalize; give examples; paraphrase; restate (in own words); summarize.                    |
| 3. Application   | the ability to use learned material in new, concrete situations; may include the application of rules, methods, concepts, principles, laws, and theories; requires a higher level of understanding than those under comprehension.   | administer; apply; calculate; chart; compute; determine; demonstrate; implement; prepare; provide; relate; report; solve; use.                              |
| 4. Analysis      | the ability to break down material into its component parts so that its organizational structure may be understood; may include the identification of parts, analysis of the relationship between parts, and recognition of the organizational principles involved; represents a higher level than comprehension and application because it requires an understanding of both the content and the structural form of the material. | analyze; break down; correlate; differentiate; discriminate; distinguish; formulate; illustrate; infer; organize, outline; prioritize; separate; subdivide. |
| 5. Synthesis     | the ability to put parts together to form a new whole; may involve the production of a unique communication, a plan of operations (research proposal), or a set of abstract relations (scheme for classifying information); stresses creative behaviors, with major emphasis on the formulation of new patterns or structure.  | adapt; combine; compile; compose; create; design; develop; devise; facilitate; generate; integrate; modify; plan; reconstruct; revise; structure.           |
| 6. Evaluation    | the ability to judge the value of material for a given purpose, based on definite criteria; contains elements of all the other categories, plus conscious value judgments based on clearly defined criteria.   | appraise; compare & contrast; conclude; criticize; critique; decide; defend; evaluate; judge; justify.  |

**Table 2. Examples of instructional Objectives Referenced to Bloom's Six Levels of Cognitive Development**

| Level            | Example Instructional Objectives  |
|------------------|---|
| 1. Knowledge     | <b>List</b> the assumptions required for truss analysis.  |
| 2. Comprehension | <b>Explain</b> the procedure for calculating member forces in a truss, using the <i>method of joints</i> .  |
| 3. Application   | <b>Calculate</b> the member forces in a truss, using the <i>method of sections</i> .  |
| 4. Analysis      | <b>Analyze</b> a roof truss, accounting for all relevant loading conditions.  |
| 5. Synthesis     | <b>Design</b> a roof truss of a specified span length, accounting for relevant loading conditions.  |
| 6. Evaluation    | For a roof clear span length, <b>compare</b> the suitability of deck-joint-truss system, deck-beam-girder system, and prestressed beam configurations, etc.; and <b>decide</b> on an optimum configuration. |

***END of COMMENTARY***