
AC 2012-3182: THE RAISE THE BAR INITIATIVE: CHARTING THE FUTURE BY UNDERSTANDING THE PATH TO THE PRESENT - EXPERIENTIAL GUIDELINES

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The “Raise the Bar” Initiative: Charting the Future Through Strengthened Experiential Guidelines

Abstract

The purpose of this paper is to provide the engineering education community with a summary of ASCE’s Body of Knowledge (BOK) Experiential Fulfillment Committee’s (BOKExFC) initial work to improve the pre-licensure attainment of experience outcomes for engineering interns. ASCE’s “experiential initiative” began in 2007 and ultimately led to the development of the *Guidelines for Attainment of Experiential Outcomes* for the outcomes with experiential expectations contained in the second edition of the civil engineering BOK. This paper provides a summary of the BOKExFC activities and emphasizes the guidance for engineering interns, supervisors, and mentors for documenting, validating, and reporting experience activities during the pre-licensure state of an intern’s career.

Introduction

In 1995 at the American Society of Civil Engineers (ASCE) Civil Engineering Education Conference, educational and professional leaders in the civil engineering community in the United States began efforts to reform civil engineering education. As a result of this initiative, ASCE Policy Statement 465—Academic Prerequisites for Licensure and Professional Practice was passed in 1998. ASCE Policy 465 calls for an increase in the educational requirements beyond the baccalaureate degree and the adoption of appropriate experience requirements as a prerequisite for the professional practice of civil engineer, i.e., ASCE’s “Raise the Bar” initiative, or *Raise the Bar* in the remainder of this paper. The Committee on Academic Prerequisites for Professional Practice (CAP³) was constituted as an ASCE Board-level committee and charged with implementation of the *Raise the Bar* initiative.

The initial step in response to this charge was the formation of the Body of Knowledge Committee in May 2002. It was charged with defining the knowledge, skills, and attitudes needed to enter the practice of civil engineering at the professional level, i.e., licensure. The BOK committee published the first edition of the *Civil Engineering Body of Knowledge for the 21st Century* (BOK1¹) in February 2004; a revised (second) edition was published in February 2008 (BOK2²). The BOK2 is a comprehensive list of 24 outcomes divided into three outcome categories: foundational, technical, and professional. The BOK2 outcomes have the desired level of achievement defined according to Bloom’s Taxonomy for the cognitive domain³. The BOK2 has recommended outcome achievement targets for each stage of the fulfillment pathway: the baccalaureate degree (B), post-baccalaureate formal education (M/30), and pre-licensure experience (E) (see Figure 1).

Detailed implementation guidelines are included in the second edition of the *Civil Engineering Body of Knowledge for the 21st Century* (BOK2²); see www.asce.org/raisethebar/reports. Policy 465 and BOK2 are aligned with the National Academy of Engineering’s *The Engineer of 2020: Visions of Engineering in the New Century*⁴ and ASCE’s *The Vision for Civil Engineering 2025*⁵.

At the request of CAP³, an exploratory ASCE Experience Committee⁶ was formed in early 2007 and directed to focus on the BOK2 outcomes with pre-licensure experience expectations. The stated expectation in the BOK2 is that “it consists of specific outcomes which must be achieved by all civil engineers prior to licensure.” The basic premise underlying the exploratory committee’s evaluation, critique, and subsequent recommendations is that the licensing process is the logical, perhaps the only, pathway for enforcing and validating the attainment of the Body of Knowledge as a prerequisite for entry into the professional practice of engineering. Consequently, the exploratory committee addressed its charges from the licensure perspective or context and focused on the outcomes in the BOK2 with experience expectations.

Still, irrespective of licensure considerations, the exploratory committee felt that in striving to attain the educational and experiential outcomes of the Body of Knowledge, the graduate civil engineer is investing in a successful and rewarding career in which progression is recognized through licensure and promotion to positions of increasing responsibility.

The exploratory committee’s conclusions acknowledged that accumulation and validation of acceptable experience are common requirements for entry into professional practice in many professions, including engineering. But in the United States, engineering experience requirements and expectations are poorly articulated, non-uniform across licensing jurisdictions, and generally lacking in structure and rigor. There is little if any resonance between the strong ASCE experiential outcomes and the current weak procedures for validating pre-licensure experience existing in the various licensing jurisdictions across the country. During presentations of *Raise the Bar* and its educational elements to engineer practitioner groups around the country, an issue often raised from the floor was that, while increasing educational expectations may be justified, the profession also needed stronger experience expectations prior to licensure. The efforts of CAP³ to strengthen experience expectations as described in this paper directly address that concern from practitioners and employers.

Included in the exploratory committee recommendations⁴ was the formation of a Body of Knowledge Experiential Fulfillment Committee with strong representation of practitioners from consulting, industrial, and agency/government environments. Recommended charges to this new committee included:

- Develop a stand-alone “Guidelines Document” using the 15 outcomes in the BOK2 with experiential expectations as a basis to be used by civil engineering interns and their mentor/supervisors during the pre-licensure state of the intern’s career. The suggested goal is to provide a resource document that interns will find both useful and user friendly in documenting, validating, and reporting their pre-licensure experience activities.

The Body of Knowledge Experiential Fulfillment Committee was constituted in the spring 2009. The efforts of this committee serve as a basis for this paper. The complete report of the committee is available at www.asce.org/raisethebar/reports .

The Civil Engineering Body of Knowledge—An Overview

A significant contribution to the second edition of the BOK (BOK2) was the adoption of Bloom's taxonomy as a mechanism to link body of knowledge outcomes to actual learning and achievement.

Bloom's taxonomy is based on three distinct domains—the cognitive, the affective, and the psychomotor. The cognitive domain deals with the recall or recognition of knowledge and the development of intellectual abilities and skills. The affective domain involves interest, attitudes, and values. The psychomotor domain relates to manipulative or motor-skills. The cognitive domain has the most direct application here because it addresses many of the conventional learning outcomes associated with engineering and is aligned well with the engineering process.

The cognitive domain within Bloom's Taxonomy has six defined levels of achievement (LOA):

Level 1—Knowledge: simple recollection of previously learned material, which may range from specific facts to complete theories.

Level 2—Comprehension: explaining or describing the meaning of learned material, including perhaps estimating possible future trends.

Level 3—Application: use learned material in new situations to solve new problems.

Level 4—Analysis: breaking down learned and new material into basic component parts or principles, including defining relationships between parts.

Level 5—Synthesis: creating new knowledge or designing new systems, either uniquely or putting together existing components to form a new whole.

Level 6—Evaluation: judging the relative merit or value of material for a defined purpose, including examining potential impacts and ramifications.

Further information and discussion of Bloom's Taxonomy can be found in Appendices F and G of BOK2 (www.asce.org/raisethebar/reports).

The BOK2 Outcome Rubric, developed using Bloom's Taxonomy, is graphically presented in Figure 1. This is a simple graphical representation of the recommended level of achievement that an individual must demonstrate for each outcome to enter into the practice of civil engineering at the professional level. Figure 1 depicts the level of achievement to be fulfilled through the bachelor's degree (B), the master's degree or equivalent (M/30), and pre-licensure experience (E) for each outcome. This paper is focused on recommendations for achieving, documenting, validating, and reporting experience activities during the pre-licensure stage (E) of an engineering intern's career.

ASCE BOK Experiential Fulfillment Committee (BOKExFC) – —An Overview

An important objective in forming the BOKExFC was to populate the committee with a diverse group of civil engineering practitioners from a variety of work environments and new to the CAP^3 organizational structure. Applications for committee membership were solicited in a variety of ASCE publications. Thirty applicants were selected to attend a one-day face-to-face workshop in January of 2009. The objectives of the workshop were to first educate the participants on the BOKExFC committee charges and expectations of committee membership, and secondly to evaluate the potential of the prospective committee members to contribute to the committee’s efforts. Following the workshop, those attending were asked to confirm their interest in and willingness to serve on the committee. From those attending the workshop, nine were selected for full committee membership plus a chair and vice chair. Fourteen requested to be corresponding members and were invited to participate in all committee conference calls. In addition to three face-to-face full committee meetings, 25 conference calls were held over a two-year period at two- to four-week intervals. The committee leadership met face-to-face to draft the BOKExFC Final Report and finalize the “Guidelines Document,” referred to as the *Guidelines* in the remainder of this paper. A detailed documentation of the committee activities can be found in Appendix C of the final report.

OUTCOME #	OUTCOME TITLE	LEVEL OF ACHIEVEMENT					
		1	2	3	4	5	6
1	Mathematics	B	B	B			
2	Natural Sciences	B	B	B			
3	Humanities	B	B	B			
4	Social Sciences	B	B	B			
5	Material Science	B	B	B			
6	Mechanics	B	B	B	B		
7	Experiments	B	B	B	B	M/30	
8	Prob Recog/Solving	B	B	B	M/30		
9	Design	B	B	B	B	B	E
10	Sustainability	B	B	B	E		
11	Contemp Issues/History	B	B	B	E		
12	Risk & Uncertainty	B	B	B	E		
13	Proj Management	B	B	B	E		
14	Breadth in CE	B	B	B	B		
15	Tech Specialization	B	M/30	M/30	M/30	M/30	E
16	Communication	B	B	B	B	E	
17	Public Policy	B	B	E			
18	Business & Public Admin	B	B	E			
19	Globalization	B	B	B	E		
20	Leadership	B	B	B	E		
21	Teamwork	B	B	B	E		
22	Attitudes	B	B	E			
23	Lifelong Learning	B	B	B	E	E	
24	Professional & Ethics	B	B	B	B	E	E

Figure 1: Graphical Representation of the BOK2 Outcome Rubric

Committee charges included the following:

Critique and Revise the BOK2 Experiential Outcomes

- Recast the BOK2 experiential outcomes into a form applicable to civil engineers in various working environments.
- Generalize to other engineering disciplines where possible.
- If appropriate, propose additional outcomes to accommodate the career paths of civil engineers.

Develop a stand-alone set of experience guidelines to be followed by a civil engineer intern during his or her pre-licensure career.

- These guidelines should include not only the substantive elements of the experiential outcomes, but also provisions for reporting, mentorship, assessment, and validation of the experience elements.

This paper focuses on the above two charges, resulting in the *Guidelines*. As used in the *Guidelines*, the term “Engineer Intern,” or EI, is a graduate engineer in the early stages of an engineering career and who has passed the Fundamentals of Engineering (FE) examination as the first step toward licensure.

Development of the *Guidelines*

Of the 24 BOK2 outcomes in Figure 1 above, nine should be fulfilled entirely through the formal educational process. These nine outcomes are designated by a “B” or “M/30” (Outcomes 1–8 and 14.)

The *Guidelines* focuses on the remaining fifteen that are referred to as the **experiential outcomes**. These outcomes, designated by an “E” in Figure 1, are summarized in Table 1 below:

Outcome 9	Design	Outcome 18	Business and Public Administration
Outcome 10	Sustainability	Outcome 19	Globalization
Outcome 11	Impacts of contemporary issues & historical perspectives	Outcome 20	Leadership
Outcome 12	Risk and Uncertainty	Outcome 21	Teamwork
Outcome 13	Project Management	Outcome 22	Professional Values and Attitudes
Outcome 15	Technical Specialization	Outcome 23	Lifelong Learning
Outcome 16	Communication	Outcome 24	Professional and Ethical Responsibility
Outcome 17	Public Policy		

Table 1: Experiential Outcomes

The EI is expected to attain the outcomes through professional work experiences whenever possible. However, EIs in some working environments may not have the opportunity to attain

certain outcomes through on-the-job experience. In such cases, EIs may attain the outcome during the first few years of their career period through other experiences, such as professional training programs and/or community/civic activities as suggested in some of the illustrative experiences included in the *Guidelines*.

The fifteen experiential outcomes are given roughly equal consideration and attention in the *Guidelines*. However, the importance of the various outcomes, and the time and attention devoted to attaining each, may vary significantly from one civil-engineering work environment to another. Examples of differing work environments include design offices, facility management, academe, regulatory agencies, etc. While opportunities for attaining outcomes such as Outcomes 20 to 24 in Figure 1 may be relatively common across all work environments, opportunities for attaining others such as 9 (Design) and 13 (Project Management) maybe quite different from one environment to another. Nonetheless, it is the expectation of the civil engineering profession that the EI will demonstrate attainment of **all** of the outcomes prior to entry into the practice of civil engineering at a professional level, whatever their work environment(s) may have been during the early stages of their career. The *Guidelines* attempt to recognize these differences in offering multiple example pathways for attainment of all the experiential outcomes.

Experiential outcome attainment is a self-directed responsibility of the EI, achieved in close consultation with supervisors, mentors and licensing boards. A mentor (who could also be a supervisor) is a colleague or associate whose experience in the subject area of an outcome enables them to guide and counsel the EI in attaining the outcome, and to validate the EI's attainment.

An essential expectation in the attainment of experiential outcomes is the notion of progression in responsibility during an EI's early career. **Progressive experience** involves successive and continued progress from initial work of simpler character to professional work of greater complexity with a higher degree of responsibility. Such experience should demonstrate to the licensing jurisdiction or other reviewing authorities the capacity of the engineering intern to review the applications of engineering principles by others and to assume responsibility for engineering work of a professional character at a level that will protect the public health, safety and welfare. The EI's experience in attaining a particular experiential outcome may not, in itself, reflect progressive experience. However, attainment of the ensemble of fifteen experiential outcomes must demonstrate progressive experience.

Responsibilities of the Engineer Intern

The fulfillment and demonstration of attainment of the experiential outcomes is the responsibility of the EI. Throughout various work environments and project assignments, and possible multiple employments, the EI should maintain ownership and assume continuity of his or her efforts to achieve and document progressive experience in the first few years of their career.

The EI should prepare and frequently update a written plan for demonstrating the attainment of all experiential outcomes. The plan should be a dynamic document, periodically revisited and revised as necessary, and reviewed with mentors and, as appropriate, with their licensing

jurisdiction. The plan should ensure development of a portfolio that documents experience and demonstrates achievement and validation of the experiential outcomes.

The EI is also responsible for developing relationships with mentors who can provide guidance, insight, and tutelage through face-to-face meetings and review of their work.

Responsibility of Supervisors and Other Mentors

Assessment and validation of the EI's attaining the experiential outcomes will require close involvement of professional mentors. For technical outcomes, supervisors and mentors are typically licensed Professional Engineers (a mentor need not be in active practice). For some of the "professional practice" outcomes, it may be appropriate for the EI to enlist and engage a non-engineer mentor with expertise in those relevant outcomes. Guidance for finding mentors from outside the engineering workplace, when appropriate, is provided in Appendix B of the *Guidelines*.

The mentor should:

- Be familiar with the expectation of the Civil Engineering Body of Knowledge, in particular with regard to the experiential outcomes.
- Provide guidance, insight, and tutelage to the EI through face-to-face meetings and review of the EI's work products, with specific reference to one or more experiential outcomes and their associated guidelines, and be mindful of the expectation of progression in professional responsibilities.
- Be cognizant of jurisdictional licensing requirements and the EI's requirement to demonstrate attainment of the experiential outcomes, and enable the EI to tailor their work assignment to this end.
- Monitor the EI's progression in professional responsibility and provide guidance to ensure that the EI's activities contribute to credible progressive experience.
- Provide written statements of assessment and validation for the EI's experience portfolio.
- At regular intervals, review with the EI the plan for attainment of the experiential outcomes and guide the EI in updating the plan to reflect changes in activities and the need for other types of outcome attainment.
- Validate, where appropriate, the EI's attainment of an outcome through appropriate activities and experiences.

Appendix C of the *Guidelines* contains expanded guidelines for supervisors and mentors. Due to the diversity and complexity of some of the experiential outcomes, it may be necessary for an EI to engage and consult a number of different mentors, even for the same experiential outcome. Mentors should advise and assist the EI in finding the appropriate expertise to validate attainment of all experiential outcomes.

Guidelines for Demonstrating Attainment of Experiential Outcomes

Procedures for attainment of the fifteen experiential outcomes are outlined in the *Guidelines*. They are based on the notions of outcomes, activities, and illustrative experiences as defined below:

- **Outcomes** – Statements that describe what EIs are expected to know and be able to do by the time of entry into the practice of civil engineering at the professional level. Outcomes define the knowledge, skills, and attitudes that individuals acquire through appropriate formal education and early-career experience.
 - **Activities** – Work efforts from a variety of engineering environments that could provide a pathway for partial or full attainment of an outcome.
 - **Illustrative Experiences** – Documentable examples that demonstrate completion of an activity.

Completion of at least one **activity** is required to demonstrate attainment of an outcome.

In the *Guidelines*, each experiential **outcome** includes a summary narrative description. Full statements of the educational and experiential components of each outcome are in Appendix J of the BOK2. Each outcome statement is followed by a list of possible **activities** that the EI could pursue to demonstrate attainment. For each activity a brief set of **illustrative experiences** demonstrates the kinds of engineering experiences that would be supportive of the activity.

Although the activities and experiences included in the *Guidelines* are intended to capture the broad diversity of engineering working environments and communicate the expected level of involvement, they are presented only as an **illustrative methodology for attainment**. They should serve as guidance to the EI in pursuing these or other similar activities and experiences reflecting the opportunities and constraints of their particular work environment, mentor interests, and possible current and future licensure board expectations. There is no expectation that the outcomes be attained in the order in which they are presented in the *Guidelines*.

Experiential Outcomes Attainment Portfolio

The *Guidelines* have been developed to assist the EI in understanding the necessary experience needed to attain the prescribed Body of Knowledge (outcomes). The EI should become familiar with and understand the *Guidelines* and suggested reporting forms (See Figures 2 and 3). The reporting of progressive experience should include a narrative describing the activities completed for each outcome. These narratives with validating signatures should be retained for possible future review by an appropriate licensing authority. The *Guidelines* provide examples of various activities that, when completed, may assist the EI in demonstrating attainment of that particular outcome. Often more than one activity will be necessary to demonstrate satisfactory attainment. Illustrative experiences outlined for an activity are to demonstrate the type and extent of experience that would most likely qualify. The EI should have the mentor sign Form 1 when the relevant experiences or activities have been satisfactorily completed. When the EI gains sufficient progressive experience that demonstrates attainment of an outcome, a mentor should sign Form 2. An EI's experience portfolio should include completed Form(s) 1 and Form 2 for each of the fifteen outcomes with experiential expectations.

Example from *Guidelines*—Outcome 9: Design

Outcome 9 (Design) received a great deal of attention from the BOKEExFC, for several reasons:

- Design experience is perhaps most closely aligned with the traditional experience expectations of licensing boards at present.
- Given the broad diversity of civil engineering work environments, attainment of the design outcome can follow quite different paths (e.g., design office vs. academe).
- The notion of education and experience in the engineering design concepts is fundamental to the engineering process, and is recognized as such by accreditation agencies as well as the licensure community.

The *Guidelines* material for the Design outcome is presented in Appendix A; the other 14 experiential outcomes have similar sections in the *Guidelines*. Note from Figure 1 that the BOK2 outcomes assign Bloom's achievement level 6 (Evaluation) to the experiential expectations of the design outcome. Appendix A also includes an example portfolio entry for this outcome.

Recommendations for Implementation of the *Guidelines*

The final report of the BOK Experiential Fulfillment Committee included recommendations for implementation of the *Guidelines*:

1. Publish the *Guidelines* on the ASCE web site and publicize its existence through internal member publications, newsletters, and announcements. This effort might include creation of a summary pamphlet providing an introductory overview of the *Guidelines*.
2. Host an ASCE workshop/colloquium, possibly as a webinar, to accompany initial publication of the *Guidelines*. The workshop would enable interested individuals to be introduced to the purpose and contents of the *Guidelines*. ASCE could establish a continuing on-line discussion board that allows participants to (1) provide feedback and ask questions about the *Guidelines* and (2) identify issues and provide recommendations for a future edition of the *Guidelines*.
3. Establish a new ASCE Experiential Guidelines Implementation Committee. Charges to the committee could include:
 - Identify the internal and external stakeholders for the *Guidelines* (possibly to include other engineering professional societies, ABET and NCEES).
 - Prepare and implement a plan to encourage EIs to use the *Guidelines*.
 - Prepare and implement a plan to encourage firms and organizations that employ engineers to incorporate the *Guidelines* in their professional development program for their EIs.
 - Prepare and implement a plan to evaluate the *Guidelines* with a test group of EIs and their mentors/supervisors. This testing would encompass a critical assessment and evaluation of (1) the activities and illustrate experiences associated with each experiential outcome and (2) the validation processes recommended in the *Guidelines*.

- Evaluate the rationale, benefits, and costs of establishing an ASCE “Body of Knowledge Experiential Fulfillment Certificate” program that would recognize an individual’s attainment of the fifteen BOK2 outcomes with experiential expectations.

The BOKExFC focused primarily on the civil engineering profession, as charged. However with an eye to the future possible adoption of the outcomes and *Guidelines* by other engineering professions, it suggested editorial modifications to the Outcomes and phrasing in the *Guidelines* that would be inclusive of the other disciplines as *Raise the Bar* becomes established within civil engineering.

Final Thoughts

As stated in the Introduction, the value of this initiative goes well beyond licensure considerations. In striving to attain the educational and experiential outcomes of the Body of Knowledge, any graduate civil engineer is investing in a successful and rewarding career whose progression is recognized through promotion to positions of increasing responsibility, whether or not licensure is involved. This initiative’s structured roadmap for growth in professional capabilities and responsibilities is of value to the engineer at whatever level it is adopted—from minimal and strictly individual self-directed progression at the entry level, through close mentoring, oversight, and documentation as shown for the Design outcome at the most aggressive level. There is no doubt that attainment of the experiential guidelines through this initiative demands special effort from both the EI and supervisors/mentors. Employers should value the opportunity to support their young engineers who wish to take charge of their career path in attaining the experiential outcomes in a structured manner. When and if outcome-based experience migrates into the licensure process, there may be resistance based on the additional effort required, compared to the present model. The BOKExFC believes that the enhanced competence and professionalism of young engineers is well worth whatever additional effort may be required.

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Appendix A

Outcome 9: Design

The portion of the BOK envisioned to be achieved through pre-licensure experience is

Level 6: ***Evaluate*** the design of a complex system, component, or process and **assess** compliance with customary standards of practice, user's and project's needs, and relevant constraints.

The post baccalaureate engineering design experience should include opportunities to employ many or all aspects of the design process, including problem definition, project and system planning, scoping, the design objective, the development of design options, standards, codes, economy, safety, constructability, operability, sustainability, and design evaluation. Experience at this level should include familiarity with interactions between planning, design, construction, and operations and should take into account design life-cycle assessment. The role of peer and senior review and of the design verification process in ensuring successful design should be emphasized to individuals at this level.

Activity 9-1 Evaluate a set of potential design conditions including potential problems, boundary conditions and performance expectations.

Defining the scope and objectives of a design, and identifying the constraints and standards applicable to it are essential to the design process. Identifying the potential problems that will interfere with a design or hinder its implementation is a similarly critical part of the design process.

Illustrative Experiences

1. Assess a design scope of work for use in a project proposal or a request for proposals.
2. Recommend a set of design criteria and performance expectations, including applicable standards and boundary conditions.
3. Assess impacts associated with non-performance of a design or system, given the potential that design conditions may be exceeded or design constraints may be modified.

Activity 9-2 Explain and defend critical design decisions within peer groups, client representatives, and public forums.

There are usually numerous ways to approach an engineering problem. Defining the appropriate approach to design is a critical part of the design process. This leads to evaluation of a variety of factors associated with the design and ultimately to selection of critical design decisions for the project based on these evaluations. Articulation of the rationale for design decisions is an essential part of the design process.

Illustrative Experiences

1. Explain the critical design decisions that are required to arrive at an appropriate design solution(s) for an engineering problem to those in responsible engineering charge of a project.
2. Summarize the design decisions reached for a project in a basis of design report or similar document, including reasons for selection and if applicable compliance with codes and standards.
3. Participate in explaining the design decisions to client representatives, including alternatives considered and reasons for decisions made including management of risks, costs, and meeting client objectives.
4. Recommend changes/revisions to a design as a result of feedback from client/regulatory/ public assessments and reviews.

Activity 9-3 Recommend a design solution for a specific set of conditions, problems, parameters, and/or boundary conditions. Design solutions include calculations, flow charts, reports, construction documents, specifications, software program design, and any other deliverable or verifiable documentation.

A design solution is defined as any system, program, product or project plan, design, specifications, cost estimate and other outcomes that represent a detailed, analytical, and engineered description of a set of conditions or solution to a problem. Developing and applying such a solution to a complex set of conditions can involve planning and engineering activities of all sorts such as scheduling, cost estimating, budgeting, resource management, quality management, risk analysis, CAD, written narrative documentation, calculations, and other analyses.

Illustrative Experiences

1. Assess the life-cycle costs and expected performance of design alternatives for a design solution or product, quantitatively addressing capital or development costs as well as long term operation support and maintenance costs.
2. Recommend the best use of different manufacturing, development, materials or construction methods for a project or design solution including advantages and disadvantages regarding cost, constructability, consistency with other system elements, and sustainability.
3. Recommend appropriate specifications from practice/industry standards, governmental agency requirements, manufacturer's standards, or other source in the demonstration of a chosen design parameter.
4. Summarize knowledge regarding federal, state, and local standards and ordinances; owner/client requirements; construction means and methods; as well as available

materials, budget, and scheduling constraints to provide a design solution and produce construction documents.

Activity 9-4 *Evaluate a design solution prepared by others for conformance with the owner's and the user's needs, utilizing objective parameters including, acceptable building codes, specifications, and other standards or regulations, or with regard to the initial set of design conditions or parameters.*

Examples of design solution(s) to similar design problems are commonly used by engineers to evaluate relevant design approaches. Each design solution must be analyzed in its entirety and/or broken down into various components to determine its functionality and applicability to the original's user's needs and those needs of the current project. It is through this process of evaluating the design solutions of others that the engineer may develop a greater understanding of the requirements and limitations of various project components and form a project approach to meet the design condition and/or parameters of the current project.

Illustrative Experiences

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|---|
| 1. Assess components of the project that meet or do not meet the design conditions of the project. (e. g. building codes, regulations, sustainability, globalization, etc.) |
| 2. Compare areas of the design solution that appear to have either excessive, appropriate or minimal associated safety factors and/or risks. |
| 3. Appraise the constructability and cost of the design solution. |
| 4. Assess the appropriateness of the design solution in comparison to the initial set of design conditions or parameters. |

Activity 9-5 *Evaluate the compromises that must be made among competing design parameters using rational approaches, and considering codes, technical papers, planning documents, statutes and regulations, permits and mitigation, specifications, and other standards.*

Compromises must be made between competing design parameters of the element or system that is being designed. A common example is life-cycle cost versus first cost. These compromises must be made in order to create a design that balances the goals of the project and the desires of the client. These compromises can be accomplished in many ways.

Illustrative Experiences

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|---|
| 1. Evaluate the life-cycle costs and performance of design alternatives for a project or product, quantitatively addressing both capital or development costs and long-term operation (support) and maintenance and serviceability costs. |
| 2. Evaluate the use of different manufacturing, development, materials or construction methods for a design including advantages/disadvantages in cost, availability, |

constructability, consistency with other system elements, and sustainability.
3. Compare the appropriate factor of safety or performance assurance measure of a system being designed, based on relevant factors and appropriate assumption of risk.
4. Evaluate appropriate, established and/or required code(s), regulatory requirement, statutes and permits, planning documents, practice manuals, or other established standard in the determination of appropriate design parameter for a project.
5. Evaluate appropriate specifications from practice/industry standards, governmental agency requirements, manufacturer's standards, or other sources in the demonstration of a chosen design parameter.

Portfolio Example for Outcome 9 - Design

Now what follows is a detailed example of how Marilyn Johnson, EI, completed Forms 1 and 2 to document attainment of Outcome 9 – Design. The completed sample forms in Figures A.1, A.2, and A.3 below reflect the following scenario.

John Smith, a project engineer at Riverplace Engineering Corp., supervised Ms. Johnson, and from August 2006 through January 2009 she acquired two relevant design experiences. John Smith has provided a statement to that effect on a Form 1 (See Figure A.1). Marilyn was then supervised by Bill Jackson of Jackson and Associates and acquired an additional significant design experience during the period February 2009 through March 2010. Bill Jackson attests to this in a second Form 1 (See Figure A.2). Note that documentation for each of the engineering experiences includes attachments to the respective Form 1. Finally, Bill Jackson has also summarized his conclusion that Marilyn has attained the design outcome as described in the *Guidelines*. His validation of outcome attainment is summarized on Form 2 (See Figure A.3).

Similar documentation would be developed by the EI and his or her mentors and supervisors for each experiential outcome. Some may only require Form 1 and Form 2 statements by one supervisor and/or mentor.

**FORM 1
List of Relevant Experiences**

Engineer Intern: **Marilyn Johnson**

Use this form to identify ONE OR MORE relevant experiences relating to ONE OUTCOME verifiable by ONE supervisor or other mentor.
Fill in only yellow and blue highlighted blocks. Blue highlighted experience description blocks will expand to accommodate text as needed.

Outcome	Relevant Experience				Experience Acquired			
	Yr Begun	Starting Month	Ending Month	Brief Description	Attachment(s)	Verifying Supervisor or Other Mentor	PE?	Date
Outcome 9 - Design See Guidelines for description.	1	Aug-06	Nov-09	Recommended appropriate specifications from practice/industry standards, governmental agency requirements, manufacturer's standards, and other sources in the support of a 4-lane, state highway bridge design over the Kaskaskia River.	A1-A36	John Smith	Y	11/17/09
	3	May-08	Jan-09	Assessed the life-cycle costs and expected performance of design alternatives for a state highway connector and bridge project, quantitatively addressing capital and development costs as well as long term operation support and maintenance costs.	B1-B17	John Smith	Y	1/29/09
Statement by Supervisor or Other Mentor Verifying Relevant Experience					Position:	Project Engineer		
Marilyn worked directly under my supervision for 29 months after joining the firm on a project team preparing a comprehensive specification package for a large turnkey highway project. She researched applicable standards and regulatory requirements, then drafted specifications to meet our company's and client's preferred format. She has also assessed life-cycle costs and expected performance on a design alternatives analysis. Her ability to take on design responsibilities has grown and I have rapidly increased her authority accordingly.					Organization:	Riverplace Engineering Corp		
					Address:	27 Water Street DeMoines, IA 21229		
					Telephone:	713-444-2975		
					Email Address:	jsmith@riverplace_ec.net		
See Attachment	NA	for continuation of Statement. If none, enter "NA".			Signature:		Date:	

Figure A.1 – Completed Form 1 for Marilyn Johnson’s First Design Activity

**FORM 1
List of Relevant Experiences**

Engineer Intern: **Marilyn Johnson**

Use this form to identify ONE OR MORE relevant experiences relating to ONE OUTCOME verifiable by ONE supervisor or other mentor.
Fill in only yellow and blue highlighted blocks. Blue highlighted experience description blocks will expand to accommodate text as needed.

Outcome	Relevant Experience				Experience Acquired				
	Yr Begun	Starting Month	Ending Month	Brief Description	Attachment(s)	Verifying Supervisor or Other Mentor	PE?	Date	
Outcome 9 - Design See Guidelines for description.		4	Feb-09	Mar-10	Participated in explaining design decisions to county highway representatives, including alternatives considered and reasons for decisions made including management of risks, costs, and meeting client objectives.	C1-C7	Bill Jackson	Y	2/3/10

Statement by Supervisor or Other Mentor Verifying Relevant Experience		Position:	Principal Engineer
Since joining our firm, Marilyn has demonstrated growing discernment and the capability to evaluate a design solution's ability to meet the various constraints imposed by regulatory requirements, our clients, and our partners. Our clients have already grown to rely on her ability to assess design alternatives and often follow her lead on choosing solutions. She has attained Outcome 9.		Organization:	Jackson and Associates, LLC.
		Address:	111 Main Street Plainfield, IA 21229
		Telephone:	713-563-3397
		Email Address:	wjackson@jalcc.com
		Signature:	
See Attachment	NA	for continuation of Statement. If none, enter "NA".	

Figure A.2 – Completed Form 1 for Marilyn Johnson’s Second Design Activity

**FORM 2
Validation of Experience and Outcome Attainment**

Engineer Intern: **Marilyn Johnson**

Use this form to identify ALL relevant experiences for ONE OUTCOME and to validate attainment of that outcome.
Fill in only highlighted blocks. Experience blocks will expand to accommodate text as needed.

Name of Validating Supervisor or Other Mentor:	Bill Jackson	Address:	111 Main Street
Employer or Organization:	Jackson and Associates, LLC.		Plainfield, IA 21229
Position:	Principal Engineer	Telephone:	713-563-3397
		Email Address:	wjackson@jalco.com

Statement by Supervisor or Other Mentor Validating Outcome Attainment

Marilyn has demonstrated growing discernment and the capability to evaluate a design solution's ability to meet the various constraints imposed by regulatory requirements, our clients, and our partners. Our clients have already grown to rely on her ability to assess design alternatives and often follow her lead on choosing solutions. She has attained Outcome 9.

See Attachment **NA** for continuation of Statement. If none, enter "NA".

"Copy" and "Paste" directly onto the lines below from blue highlighted rows on each Form 1 for this outcome.

Outcome	Relevant Experience				Experience Acquired				
	Yr Begun	Starting Month	Ending Month	Brief Description	Attachment	Verifying Supervisor or Other Mentor	PE?	Date	
Outcome 9 - Design See Guidelines for description.	1		Aug-09	Nov-09	Recommended appropriate specifications from practice/industry standards, governmental agency requirements, manufacturer's standards, and other sources in the support of a 4-lane, state highway bridge design over the Kaskaskia River.	A1-A36	John Smith	Y	11/17/09
		3	May-09	Jan-09	Assessed the life-cycle costs and expected performance of design alternatives for a state highway connector and bridge project, quantitatively addressing capital and development costs as well as long term operation support and maintenance costs.	B1-B17	John Smith	Y	1/29/09
		4	Feb-09	Mar-10	Participated in explaining design decisions to county highway representatives, including alternatives considered and reasons for decisions made including management of risks, costs, and meeting client objectives.	C1-C7	Bill Jackson	Y	2/3/10

Figure A.3 – Completed Form 2 for Marilyn Johnson’s Attainment of the Design Outcome