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 civil engineering program evaluators by clarifying and amplifying the Civil Engineering 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 Civil Engineering Program Criteria contained in the ABET/EAC Criteria. References to the “current criteria” are to those in effect for the 2011-2012 accreditation cycle and available on the ABET, Inc. web site (and as approved by the ABET Board of Directors as of October 30, 2010).

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, other team members, and appropriate program documentation.

Throughout this commentary references are made to Bloom’s Taxonomy. Bloom’s Taxonomy is not a part of the Civil 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 explicit in the Program Criteria for Civil and Similarly Named Engineering Programs (in the current criteria).

SECTION            page
ABET/EAC General Criterion 3                2
ABET/EAC Program Criteria for Civil and Similarly Named Engineering Programs  2
Knowledge of Mathematics & Science          3
Conduct Civil Engineering Experiments      3
Design a System, Component, or Process     5
Knowledge of Four Technical Areas          7
Importance of Professional Licensure       8
Concepts in Management, Business, Public Policy and Leadership 8
Faculty Requirements                      9
APPENDIX – Bloom’s Taxonomy                11
ABET/EAC Part I. GENERAL CRITERIA FOR BACCALUREATE LEVEL PROGRAMS

The details of criterion 3 are provided immediately below for easy access and to provide some context for the rest of the discussion.

Criterion 3. Student Outcomes

“The program must have documented student outcomes that prepare graduates to attain the program educational objectives.

Student outcomes are outcomes (a) through (k) plus any additional outcomes that may be articulated by the program.

(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 Part III. PROGRAM CRITERIA

Note that program criteria used to be listed as “criterion 9” but are now in the third part of the overall criteria (there is no criterion 9). Also note that program criteria are “limited to the areas of curricular topics and faculty qualifications.” This means that assessment and evaluation of the degree to which students have attained the skills described within the program criteria are not generally required. However, if the program has chosen to incorporate any of the elements of the program criteria into its student outcomes, then assessment and evaluation, as called for in Criterion 4, is required. The program criteria relevant for the 2011-12 accreditation cycle for civil engineering programs are provided immediately below.

Program Criteria for Civil and Similarly Named Engineering Programs

1. Curriculum

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

2. Faculty

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

Knowledge of Mathematics & Science

This section is a discussion of the following portion of the Civil Engineering Program Criteria:

The program must prepare graduates to apply knowledge of mathematics through differential equations, calculus-based physics, chemistry, and at least one additional area of basic science, consistent with the program educational objectives....

Reference should also be made to General Criterion 3 (student outcomes) item (a) listed above.

Mathematics through differential equations, calculus-based physics, and chemistry are considered to be part of the technical core of civil engineering and thus are explicitly required by the CE Program Criteria. Unlike previous versions of the CE Program Criteria, knowledge of probability and statistics is not explicitly required. Nonetheless, probability and statistics concepts are integral to most civil 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 course in math or probability and statistics.

The requirement for “one additional area of basic science” reflects ASCE’s intent that civil engineering graduates develop greater breadth in the basic sciences beyond the technical core subjects of physics and chemistry. Some possible additional areas of study include biology, ecology, geology, geomorphology, and geo-spatial representation—areas of significant interest and increasing importance for civil engineers. This list is by no means all-inclusive, and it is not necessary that all students within a program study the same additional area of science. However, in cases other than those listed above, it is the program’s responsibility to demonstrate that the selected area(s) of science provides breadth beyond physics and chemistry, consistent with the program objectives. In general, an advanced course in physics or chemistry (i.e., one for which a basic-level physics or chemistry course serves as a prerequisite) would not fulfill this requirement because such a course would provide additional depth rather than breadth. For the same reason, a course that is primarily engineering science in content would not fulfill this requirement. Finally, because the focus of this provision is on increased breadth in basic science, an additional course in mathematics generally would not fulfill this requirement.

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 curriculum content is sufficient to prepare graduates to 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 program should present sufficient information to demonstrate that the subject areas are adequately covered within the curriculum and that all students must take the necessary courses in order to graduate.

Conduct Civil Engineering Experiments

This section is a discussion of the following portion of the Civil Engineering Program Criteria:

The program must prepare graduates to... conduct civil engineering experiments and analyze and interpret the resulting data....

Reference should also be made to General Criterion 3 (student outcomes) item (b) listed above.

The Civil Engineering Program Criteria differs from General Criterion 3(b) in that there is no mention of an
ability to *design experiments* and there is an additional requirement of student exposure to *civil engineering* experiments. The design of experiments is not emphasized in the Program Criteria, because civil 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 and the Standard Methods for the Examination of Water and Wastewater. Nonetheless, it is important to recognize that the absence of any reference to experimental design in the Civil 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 design of experiments must reflect the putting together of parts to form a new whole.

Compliance with the program criterion can be demonstrated through laboratory experiences that are consistent with the standards-based testing used in the civil 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 experiment 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 or highway. 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 criterion.

However, because the requirement for experiment design occurs only in the General Criteria, there is no requirement for students to design experiments in a civil 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 a civil engineering context* and then analyzing, interpreting, and applying the data. Compliance should be demonstrated through showing that graduates have sufficient exposure to laboratory experiences within the curriculum and that all students must obtain that level of exposure in order to graduate. Elements to look for may include, but are not limited to:

Understanding of the objectives and procedures associated with an experiment.

- The conduct 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 experimental procedures and analysis of results consistent with a real-world civil engineering problem or situation.

Note that the final bullet item should be present in some form, but otherwise not all elements of the list need to be present exactly as described. Each program should be evaluated on a case by case basis to determine if the students’ laboratory experiences are in line with the program criteria.

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:

- The extent to which the subject matter lends itself to accurate simulation.
- The extent to which the simulation replicates the actual physical experiences of setup, measurement, and data collection.
- The nature of student interaction with the simulation.
- The students’ abilities acquired through the simulation.
- Students’ satisfaction with their abilities gained through the simulation.

**Design a System, Component, or Process**

This section is a discussion of the following portion of the Civil Engineering Program Criteria:

**The program must prepare graduates to…design a system, component, or process in more than one civil engineering context…**

Reference should also be made to General Criterion 3 (student outcomes) item (c) listed above.

**Definition of Design**

The ABET definition of engineering design (see item (b) in Criterion 5. Curriculum) 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.”

**Discussion of Design**

This definition should form the basis for evaluation of the design-related provisions of the Civil Engineering Program Criteria.

Consistent with Bloom’s Taxonomy (see appendix), the verb “design” in this criterion implies that the expected level of achievement is Level 5, Synthesis. The program should demonstrate that students have adequate exposure to design in the curriculum that they are prepared to engage in design, as defined, in more than one civil engineering context. Elements to look for in evaluating students design experience include, but are not limited to:

- 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. Such a requirement would place an unrealistically heavy burden on both faculty and students.

- 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 design computations. It is both typical and appropriate for a design problem to have a relatively narrow range of “correct” solutions. Similarly, the term optimal (or optimally) should be interpreted with caution. While some engineering design problems may have optimal solutions, others (such as ill-defined systems problems) may not have an optimal solution per se. Some engineers might even argue that no problems other than the most simplistic have true optimal solutions. In this context, incorporation of a formal optimization process is not indicated.

- 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 civil 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 civil 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 civil engineering context, manufacturability is generally interpreted as constructability.

The intent of the Civil Engineering Program criterion cited above is that the curriculum include design in at least two civil engineering contexts that are different from one another. One unambiguous way to satisfy this criterion is for the program to require its students to experience design in more than one civil engineering technical area; e.g., structural engineering and geotechnical engineering. For example, a program that requires its students to design both a reinforced concrete building frame (a structural engineering context) and a deep foundation (a geotechnical engineering context) is in compliance. Conversely, a program that requires its students to design only a reinforced concrete structure and a steel structure would not be in compliance, because the design process for steel and concrete structures is so similar.

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”.

Page 6 of 11
Consistent with Bloom’s Taxonomy, the verb “design” in this provision of the Civil Engineering Program Criteria implies that the expected level of achievement is Level 5, Synthesis.

Knowledge of Four Technical Areas

This section is a discussion of the following portion of the Civil Engineering Program Criteria:

The program must prepare graduates to... apply knowledge of four technical areas appropriate to civil engineering....

For this part of the program criteria, there is no related statement in Criterion 3.

Through this provision, ASCE ensures that every civil engineering graduate has sufficient relevant technical breadth to be considered a civil engineer.

Seven generally recognized civil engineering technical areas include:

- structural
- geotechnical
- environmental/sanitary
- transportation
- hydraulics/hydrology/water resources
- surveying/measurements
- construction

It is entirely permissible, however, for programs to develop their graduates’ technical breadth through coursework in other subject areas. The field of civil 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, if a program’s four technical areas include one or more subjects not listed above, the program (not the evaluator) is responsible for demonstrating that its technical areas are indeed “appropriate to civil engineering.”

Some possible justifications for a non-standard curricular area might include the following:

- ASCE has an institute or technical division in the technical area.
- ASCE publishes a journal in the technical area.
- ASCE sponsors specialty conferences in the technical area.
- There are civil engineering consulting firms that specialize in the technical area.

Again, this list is not intended to be all-inclusive; many other legitimate justifications are possible. Ultimately, the program must provide the information on which a well-reasoned judgment can be made—and the
evaluator must make the judgment. This judgment must balance the desirability of curricular innovation against the need for relevant technical breadth in all civil engineering graduates. The judgment may not be based on the evaluator’s personal view of what civil engineering should or should not be.

Consistent with Bloom’s Taxonomy, the verb “apply” in this provision of the Program Criteria implies that the expected level of achievement is Level 3, Application. The program needs to demonstrate that curricular content is sufficient to prepare graduates to apply concepts and principles in all four designated technical areas to solve relatively straightforward problems. They must demonstrate that all students obtain this exposure in order to graduate.

Note that 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 the same four areas.

Importance of Professional Licensure

This section is a discussion of the following portion of the Civil Engineering Program Criteria:

The program must prepare graduates to...explain the importance of professional licensure.

As with the previous phrase, there is no direct linkage between this phrase of the program criteria and Criterion 3.

Consistent with Bloom’s Taxonomy, the verb “explain” in this criterion implies that the expected level of achievement is Level 2, Comprehension. Graduates should be able to explain the unique nature of civil engineers’ responsibility to the general public and the consequent emphasis on professional licensure in civil engineering professional practice.

As discussed above, curricular content must be present which is addressed to the importance of licensure so that all graduates are exposed to the concept.

Concepts in Management, Business, Public Policy and Leadership

The following portion of the Civil Engineering Program Criteria pertains to this outcome:

The program must prepare graduates to…explain basic concepts in management, business, public policy, and leadership.

The three forms of management most relevant to civil engineering are as follows:

- **Project management.** Basic concepts in project management include project manager responsibilities, defining and meeting client requirements, risk assessment and management, stakeholder identification and involvement, contract negotiation, project work plans, scope and deliverables, budget and schedule preparation and monitoring, interaction among engineering and other disciplines, quality assurance and quality control, and dispute resolution processes.

- **Construction management.** Basic concepts in construction management include owner-engineer-contractor relationships; project delivery systems (e.g., design-bid-build, design-build); estimating construction costs; bidding by contractors; labor and labor management issues; and construction processes, methods, systems, equipment, planning, scheduling, safety, cost analysis, and cost control.

- **Asset management.** Asset management seeks effective and efficient long-term ownership of capital facilities via systematic acquisition, operation, maintenance, preservation, replacement, and
disposition. Basic concepts include optimizing life-cycle performance, minimizing life-cycle costs, achieving maximum stakeholder benefit, and the use of tools and techniques such as design innovations, new construction technologies, materials improvements, geo-mapping, database management, value assessment, performance models, web-based communication, and cost accounting.

Basic **business** concepts that are typically applied in the private, government and non-profit sectors include legal forms of ownership, organizational structure and design, income statements, balance sheets, decision (engineering) economics, finance, marketing and sales, billable time, overhead, and profit.

Basic **public policy** and **public administration** concepts include the political process, formulation of public policy, laws and regulations, funding mechanisms, public education and involvement, government-business interaction, and the public service responsibility of professionals.

**Leadership**, which differs from and complements management, requires broad motivation, direction, and communication skills. Desirable behaviors of leaders, which can be taught and learned, include earning trust, trusting others, formulating and articulating vision, communication, rational thinking, openness, consistency, commitment to organizational values, and discretion with sensitive information.

Consistent with Bloom's Taxonomy, the verb "explain" in this criterion implies that the expected level of achievement is Level 2 (Comprehension). Graduates must be able to explain some (but not all) of the key concepts in any one of the three management areas listed above. As an alternative, graduates’ ability to explain generic, business-oriented management concepts (e.g., those acquired from a management course outside of the engineering program) also represents full compliance with this criterion.

It is not necessary for the program to offer one or more courses explicitly devoted to management, business, public policy, or leadership. Rather, management topics may be integrated into other courses or curricular experiences.

**Faculty Requirements**

This section is a discussion of the following portion of the Civil Engineering Program Criteria:

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

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 at least 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 civil 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.

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 in the table could include state/ of licensure, discipline (if appropriate), date of initial licensure, and the expiration date of the license.

Relevant professional licensure may be in a major civil engineering discipline—e.g., structural or environmental engineering. Licensure in a discipline closely related to the field in which the faculty member is teaching design may constitute relevant licensure but may not 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 certain design courses, even if not sufficient to satisfy the licensure requirement.

Certifications are available in many disciplines and specialties. They are not licensure and cannot be used to fully satisfy this requirement. However, certification indicate proficiency/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 a 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 a civil 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 he/she is teaching design. For instance, the related field may be chemical or mechanical engineering for environmental engineering faculty. Of equal or greater importance than the specifics of his/her education is what the individual has accomplished since obtaining the related education. In the case of an unlicensed faculty member, a relevant question might be whether the person appears to have enough experience to be eligible to be licensed.

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.
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

<table>
<thead>
<tr>
<th>Level</th>
<th>Definition</th>
<th>Illustrative Verbs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Knowledge</td>
<td>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.</td>
<td>define; describe; enumerate; identify; label; list; match; name; reproduce; select; state.</td>
</tr>
<tr>
<td>2. Comprehension</td>
<td>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.</td>
<td>classify; cite; convert; describe; discuss; estimate; explain; generalize; give examples; paraphrase; restate (in own words); summarize.</td>
</tr>
<tr>
<td>3. Application</td>
<td>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.</td>
<td>administer; apply; calculate; chart; compute; determine; demonstrate; implement; prepare; provide; relate; report; solve; use.</td>
</tr>
<tr>
<td>4. Analysis</td>
<td>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.</td>
<td>analyze; break down; correlate; differentiate; discriminate; distinguish; formulate; illustrate; infer; organize, outline; prioritize; separate; subdivide.</td>
</tr>
<tr>
<td>5. Synthesis</td>
<td>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.</td>
<td>adapt; combine; compile; compose; create; design; develop; devise; facilitate; generate; integrate; modify; plan; reconstruct; revise; structure.</td>
</tr>
<tr>
<td>6. Evaluation</td>
<td>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.</td>
<td>appraise; compare &amp; contrast; conclude; criticize; critique; decide; defend; evaluate; judge; justify.</td>
</tr>
</tbody>
</table>

### Table 2. Examples of Instructional Objectives Referenced to Bloom’s Six Levels of Cognitive Development

<table>
<thead>
<tr>
<th>Level</th>
<th>Example Instructional Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Knowledge</td>
<td>List the assumptions required for truss analysis.</td>
</tr>
<tr>
<td>2. Comprehension</td>
<td>Explain the procedure for calculating member forces in a truss, using the method of joints.</td>
</tr>
<tr>
<td>3. Application</td>
<td>Calculate the member forces in a truss, using the method of sections.</td>
</tr>
<tr>
<td>4. Analysis</td>
<td>Analyze a truss bridge, accounting for all relevant loading conditions.</td>
</tr>
<tr>
<td>5. Synthesis</td>
<td>Design a truss bridge of a specified span length, accounting for relevant loading conditions.</td>
</tr>
<tr>
<td>6. Evaluation</td>
<td>For a bridge of specified span length, compare the suitability of truss, plate girder, and box girder configurations; and decide on an optimum configuration.</td>
</tr>
</tbody>
</table>