
AC 2011-1018: HUMANITIES AND SOCIAL SCIENCES WITHIN CIVIL ENGINEERING CURRICULUM

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Humanities and Social Sciences within Civil Engineering Curriculum

Abstract

Many programs struggle with how to accomplish all that is required in the current Body of Knowledge (BOK) while possibly facing decreasing credit hours. Some programs are already beginning to investigate how to possibly add additional outcomes listed under the new American Society of Civil Engineers (ASCE) BOK II document knowing that some of those outcomes will migrate eventually into the ABET Civil Engineering (CE) program criteria. Two of the possible new outcomes focus on humanities and social sciences.

How to do more with less (people, time, and resources) is a common theme on many campuses across the country especially with the current economic crisis. Many programs will feel that there is already enough coverage of humanities and social sciences within the core curriculum such that they do not need to worry about demonstration of these outcomes. However, the outcomes as listed in the BOK II would require demonstration of the importance of humanities and the incorporation of social sciences knowledge into the professional practice of civil engineering.

This paper will provide a methodology that one Civil Engineering program is using to address coverage of humanities and social sciences beyond the courses that might be in the core curriculum since programs will need to show how humanities and social sciences are incorporated into engineering solutions. The program is beginning the process now because they believe that the new outcomes in the BOK II are justified and needed; and therefore, they should not wait until the new outcomes become part of the official CE Program criteria to begin demonstrating accomplishment. This paper will present the rubrics used, the results (data) of these first assignments, the assessment, and the changes being incorporated based on the assessment. The key is early development of detailed rubrics that most of the faculty can initially agree with such that optimal points within the curriculum are selected to collect data. The initial rubrics may need to be updated each cycle to improve assessment focus and efficiency.

1.0 Introduction

The American Society of Civil Engineers (ASCE) recognized the lack of certain knowledge and skills among civil engineering graduates, while at the same time engineering programs were facing pressure to decrease credit hour requirements in undergraduate curriculums. ASCE formed a committee to study and develop a Civil Engineering Body of Knowledge (BOK)¹ to document the requisite knowledge, skills, and attitudes necessary for future civil engineers. Two key areas that resulted from the BOK and an effort to demonstrate the BOK outcomes by the ASCE Curriculum Committee² were a need to define expected performance levels by these new engineers through Bloom's taxonomy³ as well as the addition of four new outcomes focused on additional professional topics and discipline depth. Very quickly it was determined by most programs and ASCE that the discipline depth could only occur at the Master's level.

The additional professional skills above what even ABET⁴ EC2000 requires reflect greater recognition of the importance of the development of professional skills at the time of bachelor's level graduation.

The heavy discussions surrounding the First Edition of the BOK led to the forming of the Second Edition of the BOK committee⁵ to address:

- using Bloom's taxonomy (read action verbs) to define level of demonstration
- the splitting ABET outcomes into smaller focused outcomes (i.e., ABET Outcome 1 is "an ability to apply knowledge of mathematics, science, and engineering"⁴ which became in BOK II outcomes 1-Mathematics, 2-Natural Sciences, 5-Materials Science, and 6-Mechanics)
- the addition of new outcomes that review of BOK I highlighted as also needed (sustainability, historical perspectives, globalization, humanities, social sciences, risk and uncertainty, and breadth in civil engineering areas).

The ASCE Fulfillment Committee⁶ is currently studying implementation techniques for the new outcomes as well as implementation of adjusted levels of outcome demonstration at the undergraduate level using Bloom's taxonomy (Appendix I). It is only a matter of time that some, if not all of these new outcomes and levels of demonstration occur within ABET program criteria as is being called for by some⁷ or CE program criteria as the new outcomes in BOK I did in 2008 just four years after BOK I was in print. Some even hint that changes every six years are reasonable to consider.⁷

How does a program add the new topics? The Department of Civil Engineering at The University of Texas at Tyler (UT Tyler) which is the newest program to be added to the College of Engineering and Computer Science began hiring faculty and admitting students in 2005. The students who made up the first graduating class in 2008 were actually admitted into the mechanical engineering program in 2004 with the anticipation of hiring the first CE faculty member. There were twelve students who declared themselves as future CE students before the department officially existed. This placed these students on a path to graduate in May 2008. The timing could not have been better considering that the next scheduled ABET visit for UT Tyler was fall 2008 because of the previous accreditation visit in 2002 for the electrical and mechanical programs. The program was able to meet all expectations and received accreditation through ABET in 2009, retroactive to May 2008.⁸ Because of last minute changes needed for the most recent ABET visit to meet all civil engineering program criteria generated outcomes, the program has decided to move forward now to begin determining how best to demonstrate BOK II outcomes that are currently not covered anywhere. The BOK II elevates design to the Bloom's level of evaluate; elevates sustainability to an outcome rather than covering it through consideration of the engineering constraints during design; adds historical perspectives when considering contemporary issues; elevates globalization to an outcome rather than having it as part of a broad education that includes the impact of engineering solutions in a global, economic, environmental, and societal context; elevates humanities and social sciences to an outcome rather than having it covered within a broad general education; elevates risk and uncertainty through the use of probability and statistics to an outcome; and elevates breadth in four civil engineering areas to an outcome.⁵

The programs in Texas have also experienced credit hour decreases in 2007 from approximately 134 to 128 credit hours and now the state legislature is considering decreasing all programs to include engineering to 120 credit hours. How does a program continually add the new topics with possible decreasing credit hour mandates?

2.0 Positions on Humanities and Social Sciences

2.1 ABET

ABET Outcome 3h (Table 1) requires that students demonstrate they have “the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.”⁴ The CORE as it referred to at some universities is the location that most students experience humanities and social sciences.

Table 1 ABET Criterion 3 (a-k)

Demonstration (incl. Process & Measurements) that Graduates have:
(a) ability to apply knowledge of math, engineering, and science
(b) ability to design and conduct experiments
(b) ability to analyze and interpret data
(c) ability to design system, component or process to meet needs within realistic constraints such as regulatory, economic, environmental, social, political, ethical, health and safety, constructability, and sustainability.
(d) ability to function on multi-disciplinary teams
(e) ability to identify, formulate, and solve engineering problems
(f) understanding of professional and ethical responsibility
(g) ability to communicate effectively
(h) broad education
(i) recognition of need by an ability to engage in life-long learning
(j) knowledge of contemporary issues
(k) ability to use techniques, skills, and tools in engineering practice

2.2 BOK I

The first committee on the BOK took a futuristic approach on infrastructure and environmental needs to develop a list of outcomes to elevate the depth and breadth of knowledge, skills, and attitudes required of civil engineers desiring licensure. The first eleven outcomes directly related to ABET’s eleven outcomes (3a-k). The twelfth outcome called for “an ability to apply knowledge in a specialized area related to civil engineering.”¹ Quickly all realized that this could not occur at the bachelor’s level. The additional outcomes were:

- “an understanding of the elements of project management, construction, and asset management;”
- “an understanding of business and public policy and administration fundamentals;” and,
- “an understanding of the role of the leader and leadership principles and attitudes.”¹

The end result was additions to the Program Criteria for Civil and Similarly Named Engineering Programs: “explain basic concepts in management, business, public policy, and leadership.”⁴ They were accounted for within the UT Tyler Department of Civil Engineering Program Outcome 9 (Table 2). The current requirements for humanities and social sciences did not change.

Table 2 The UT Tyler CE Program Outcomes

Graduates:
1. Can apply knowledge of traditional mathematics, science, and engineering skills, and use modern engineering tools to solve problems.
2. Can design and conduct experiments, as well as analyze and interpret data in more than one civil engineering sub-discipline.
3. Can design systems, components, and processes and recognize the strengths and areas for possible improvement of their creative designs within realistic constraints such as regulatory, economic, environmental, social, political, ethical, health and safety, constructability, and sustainability.
4. Can work independently as well as part of a multidisciplinary design team.
5. Can identify, formulate, solve and <u>evaluate</u> engineering design problems using engineering models in the four of the five sub-disciplines civil engineering: structural engineering, transportation engineering, construction management, hydrology and/or environmental engineering.
6. Can analyze a situation and make appropriate professional and ethical decisions.
7. Can demonstrate effective oral, written, and graphical communication skills.
8. Can demonstrate a commitment to learning and continued professional development outside the classroom, incorporate contemporary issues and <u>historical issues</u> during problem solving, and determine the impact of engineering solutions in a global and societal context.
9. Can explain professional practice attitudes, leadership principles and attitudes, management concepts and processes, and concepts of business, public policy, and public administration.
10. Can demonstrate the importance of humanities in the professional practice of civil engineering
11. Can demonstrate the incorporation of social sciences knowledge into the professional practice of civil engineering
12. Can use the knowledge of material sciences to solve problems appropriate to civil engineering
13. Can analyze and solve problems in solid and fluid mechanics
14. Can apply principles of sustainability to the design of traditional and emergent engineering systems
15. Can apply the principles of probability and statistics to solve problems containing uncertainties and risk assessment

2.3 BOK II

As mentioned above there are a number of additional topics that have been elevated to an outcome which are represented in the UT Tyler Department of Civil Engineering Program Outcomes 10-15 (Table 2) - specifically humanities (10) and social sciences (11). BOK II (Appendix I) requires demonstration of the importance of humanities in the professional practice of engineering and demonstration of the incorporation of social sciences knowledge into the professional practice of engineering. Programs will no longer be able to assume that students are using their social science and humanities experiences to influence their solutions within civil engineering. The students will have to demonstrate that they are considering humanities and social sciences within their solutions.

Every program that the author has visited with as a peer or a ABET Program Evaluator (PEV), the ability to have other university level educational programs provide assessment data for specific program outcomes has been problematic. If a program is to demonstrate a humanities or social sciences outcome, civil engineering programs will need to develop methodologies within junior and senior courses that lead students to being able to apply their experiences in social sciences and humanities to improve their civil engineering designs. No one has stated a specific timeline for incorporation of these new BOK II outcomes within the CE program criteria; however, there is an ASCE committee studying how to fulfill the BOK II requirements.⁶

2.4 The University of Texas at Tyler

Just the inclusion of humanities and social sciences outcomes within the BOK II should be enough reason for CE programs to begin considering implementation strategies. However, additional reasons may exist at the local university. How well do the humanities and social sciences Program Outcomes match with university goals and objectives? The President's strategic plan at UT Tyler specifically mentions the importance of many of the same additional outcomes in the BOK II.⁹ The importance of the humanities within the mission, goals, and strategic plan is shown below:

“The UT Tyler vision is to be nationally recognized for its high quality education in the professions and in the humanities...its graduates will understand and appreciate human diversity and the global nature of the new millennium.” ...

“ the University develops the individual's critical thinking skills, appreciation of the arts, humanities and sciences, international understanding for participation in the global society, professional knowledge and skills to enhance economic productivity, and commitment to lifelong learning.” ...⁹

The University has recently developed a number of new initiatives as part of its Southern Association of Colleges and Schools (SACS) reaccreditation such as the Global Awareness Through Education (GATE) program. The University will provide students the opportunity for multidisciplinary exploration of global issues through the GATE program: “Living and Learning Communities... for students to be exposed to global and cultural issues in their programs of study... broadly engaged in globally enhanced learning opportunities and cross-cultural experiences...”⁹ Even the UT System's strategic plan has a major category: “3) Enriching society through arts and cultural contributions...”⁹ Additionally, two of UT Tyler's major strategic planning goals focus on the goals of humanities and social sciences: 1) UT Tyler “will promote excellence in scholarship, research, creative endeavor, and innovation; 2) UT Tyler “will serve the community of East Texas and beyond.”⁹

The framework for accomplishing the strategic plan falls into six key goals with the Teaching and Learning goal highlighting the need to have students demonstrate the

importance of humanities and a consideration for social sciences within civil engineering solutions.

“Goal One: TEACHING AND LEARNING

...a variety of innovative pedagogies consistent with Boyer’s paradigm of “the scholarship of integration; the scholarship of application; and the scholarship of teaching” (Scholarship Reconsidered, 1990, p. 16);...unusual learning opportunities that promise success for a broader spectrum of learners. UT Tyler’s core curriculum includes courses from a variety of disciplines that require students to enhance their critical thinking skills; understand ethical systems; acquire knowledge and its application to the exploration of social, economic, cultural, or scientific issues; and effectively communicate...To these ends we will employ the following strategies:

Curriculum (the strategies that apply):

- Create in every college new or redesigned programs of superior quality and relevance that foster intellectual inquiry and critical thinking and that prepare students to be innovative and successful citizens in a global society.
- Create transformational learning opportunities such as ... service learning that actively engages students in the discovery, expansion, and application of knowledge within their disciplines, across disciplines, and with respect to global issues.
- Instill commitment to global citizenship by developing curricula that enhance students’ understanding of the worldwide community of people and cultures.
- Extend opportunities for technological and scientific knowledge and fluency and increase students’ participation in disciplines related to Science, Technology, Engineering, and Mathematics (STEM).”⁹

Therefore, the inclusion of new outcomes on humanities and social sciences assists the university in meeting its goals and objectives. Many universities have similar goals and objectives.

3.0 Demonstrating the Humanities and Social Sciences Outcomes

Since the program uses embedded indicators as its primary assessment method and the other assessment methods to provide additional data points, the program started the process similar to development of all of its embedded indicators for the other outcomes. During a faculty meeting, the two outcomes were listed on the whiteboard and the definition of what needed to be demonstrated (action verb) by each outcome. Faculty then volunteered courses that every student takes, even if not their own, where they thought the outcome could be demonstrated as well as the type of assignment. The goal was three to four assignments to begin the process of developing the assignment, collecting the

assignment, assessing the student demonstration of the outcome, and determining adjustments to the assignment for the next cycle of data collection. The list of assignments to consider and use if appropriate for the first cycle are provided in Table 3.

Table 3. Humanities and Social Sciences Embedded Indicators

Program Outcome	Course	Assignment
10. Demonstrate the importance of humanities in the professional practice of engineering		
	CENG 4339, Construction Management	Context sensitive design
	CENG 4115, Senior Design I	Aesthetics
	CENG 3371, Intro to Environmental Engineering	Environmental issues effect on laws, philosophy of saving the wetlands, etc.
11. Demonstrate the incorporation of social sciences knowledge into the professional practice of engineering		
	CENG 3351, Transportation Engineering	Dilemma zone decisions
	CENG 3371, Intro to Environmental Engineering	Florida – everglades
	CENG 4351, Traffic Engineering	Traffic congestion
	CENG 4339, Construction Management	Public perceptions of bid process

Since these outcomes are similar to the professional outcomes^{10,11} in the difficulty with assessing, the program immediately developed performance criteria to use during the first cycle of collecting data (Tables 4 and 5). The faculty learned during its first year of assessment that if the entire team does not understand what they are assessing against, the data collected is usually not focused enough to allow for accurate assessment of whether students demonstrated the outcome. If the developed rubrics do not provide the desired input during the assessment process, then they are adjusted prior to the next data collection cycle.

4.0 Results

This is the first year of data collection for the humanities and social sciences outcomes. Therefore, some of the embedded indicators have not been collected since they are within spring courses (Table 6). Normally the program waits until the end of the academic year to assess all of the collected embedded indicators for each outcome, but since these outcomes are new, the faculty looked at what had been collected after the fall semester to provide adjustments prior to the start of the spring semester. The assignments that actually used the rubric when developing the assignment and then filled out the rubric as part of the assessment developed a better assignment that demonstrated the outcome. The assignments that did not use the rubric were asked to fill-out the rubric and add it to the outcome assessment of the assignment. Each assignment does not need to cover all

criteria within the rubric, but multiple assignments do need to demonstrate each criterion within the rubric.

Table 4. Outcome 10: Humanities: Demonstrate the importance of the Humanities in the professional practice of Civil Engineering using homework, design teams, senior design, papers, and oral presentations.

Performance Criteria	Unacceptable	Needs Improvement	Acceptable	Superior
Define key concepts from the humanities (philosophy, history, literature, visual and performing arts, language, and religion)				
Explain key concepts of humanities and their relationship to Civil Engineering problems and solutions				
Demonstrate the importance of the humanities on the professional practice of Civil Engineering (such as incorporating application of philosophy into engineering ethics, the visual arts into the aesthetics of structures, language into the globalization of engineering, and history in the study of the past accomplishments of society through civil engineering)				

Table 5. Outcome 11: Social Sciences: Demonstrate the importance of the Social Sciences in the professional practice of Civil Engineering using homework, design teams, senior design, papers, and oral presentations. (courses such as transportation, environmental, capstone, or major design experience)

Performance Criteria	Unacceptable	Needs Improvement	Acceptable	Superior
Define key concepts from more than one area of the social sciences (economics, political science, sociology, and psychology)				
Can explain key concepts of the social sciences and their relationship to Civil Engineering problems and solutions				
Can demonstrate the importance of the social sciences on the professional practice of Civil Engineering (such as economics, safety and security, or environmental considerations)				

Table 6. Results of the Humanities and Social Sciences Embedded Indicators

Program Outcome	Course	Assignment	Results
10. Demonstrate the importance of humanities in the professional practice of engineering			
	CENG 4339, Construction Management	Context sensitive design	Exam question. Required students to explain how implementing context sensitive solutions can have a direct benefit on society and give an example (cultural, environmental, aesthetic features) on how it can be accomplished. Success. Average 89.1% on exam question. Acceptable results for the third requirement in the rubric.
	CENG 4115, Senior Design I	Aesthetics	The section of the report is not complete since the course director decided to carry over into Senior Design II.
	CENG 3371, Intro to Environmental Engineering	Environmental issues affect on laws, philosophy of saving the wetlands, etc.	Spring, provide results at conference
11. Demonstrate the incorporation of social sciences knowledge into the professional practice of engineering			
	CENG 3351, Transportation Engineering	Dilemma zone decisions	Spring, provide results at conference
	CENG 3371, Intro to Environmental Engineering	Florida – everglades	Spring, provide results at conference
	CENG 4351, Traffic Engineering	Traffic congestion	Group Paper. How road pricing can affect social behavior. Success. Average 100%. Acceptable results for all three criteria in rubric.
	CENG 4339, Construction Management	Public perceptions of bid process	Essay. Explain a branch of social science that applies to engineering, how it can be incorporated into professional practice, and why having an understanding of this social sciences discipline will help them to become better engineers. Success. Average 73%. Acceptable results for all criteria in rubric.
	CENG 2336, Geomatics	Property location	HW Essay. Reflect on how GIS can be applied in selecting the “best” location for a property. Develop three criteria to use in site selection: how criteria are relevant, influences location, how to obtain data, validity of data. Success. Average 85.2%. Acceptable results for all three criteria in the rubric.

Note that CENG 2336 Geomatics provided an embedded indicator for the Social Sciences outcome that was not assigned. The instructor followed the program director's guidance to provide embedded indicators for any new outcomes if possible. This process ensures that during the review of all embedded indicators for an outcome at the end of the spring semester that the best possible set of embedded indicators can be established in a shorter amount of time. The final results of this first cycle of data collection for the humanities and social sciences Program Outcomes are not possible until the end of the spring semester; however, they will be presented at the annual conference. The current available results are acceptable for the first time of collecting embedded indicators for these outcomes, but adjustments will be required to ensure better student demonstration of each outcome. First, the rubric needs a range of performance that properly defines the Unacceptable, Needs Improvement, Acceptable, and Superior categories (being finalized and will be presented at the conference). Second, the CENG 4351 assignment for the Social Sciences Program Outcome needs to be an individual assignment. Third, the CENG 4339 assignment should be changed to an assignment that can cover more than one of the criteria in the Humanities rubric (i.e., more than just aesthetics).

5.0 Lessons Learned

Assessment of some outcomes is not easy without an agreed upon rubric by the faculty; otherwise, each member of the team will have their own idea of what constitutes demonstration of the outcome. A defined range to describe performance levels improves assessment.

Students generally know how to demonstrate the use of mathematics and science to accomplish an objective, but when it comes to the softer skills associated with topics such as humanities and social sciences, the essay is the best method of demonstration. The use of rubrics to focus the questions and assignments results in more focused student work that more clearly demonstrates accomplishment of the outcome.

Gloria Rogers, formerly of ABET, has always said that a program only needs to demonstrate an outcome only once, but the crafting of that assignment and the demonstration by the students must hit the mark.¹² However, to get to that point in the curriculum where the demonstration occurs (senior year?), the students have to grow the correct skill set. The UT Tyler Department of Civil Engineering decided to have embedded indicators collected throughout the curriculum to show the development of the required skill set. If the development of the required skill set cannot be shown, then the program knows exactly where to start with course or program changes. The same reasoning is why the program is starting early to learn how best to craft the assignment and in what courses to best demonstrate these new outcomes. The assignment of embedded indicators to certain courses and the request for all courses to look for opportunities to demonstrate new outcomes leads to the best possible minimal set of embedded indicators.

If the students do not begin to wrestle with an outcome early in the curriculum, maybe as early as freshman year, they usually do not demonstrate well the outcome during the senior year.¹³ Engineers who do not consider the affect on the general population during problem solving will create unacceptable solutions that result in a waste of money and time.¹⁴ Sharing the desired behavior (the rubrics or grading sheets or cut sheets) with the students and the reason for the assignment has improved their affect on certain assignments, especially ones that in the past were just not done by some students.

6.0 Conclusions

The Core curriculum provides the foundation in humanities and social sciences, but those courses cannot be held responsible for demonstrating the application of humanities and social sciences knowledge during civil engineering problem solving. Only the engineering faculty can properly bridge that gap by requiring their students to apply knowledge developed earlier in the curriculum during the problem solving process. However, faculty must be aware of when their students typically take core courses. With an accurate understanding of current skill sets that the students bring to the classroom, the faculty can develop the desired ability to apply humanities and social science skills to engineering solutions with assignments throughout the curriculum that build to the final desired level of performance. Students who are better prepared to consider humanities and social sciences knowledge within engineering solutions are much better prepared to enter into professional practice. Every engineering solution interacts with the social fabric of society.

Development of rubrics before selecting the location for collection of embedded indicators will improve the quality of the embedded indicators collected. Without the faculty being in agreement as to what it means to demonstrate an outcome, each instructor will collect data that might not demonstrate the outcome at the proper level. Programs that have a plan to start early and develop detailed rubrics prior to collecting data will be successful in developing the assignment, collecting the data, assessing the data against the rubric, and making the necessary adjustments to improve the process (closing the loop) during the next data collection cycle. The process is proving successful as the program begins to demonstrate the importance of humanities and incorporation of social sciences in engineering solutions. Programs can add additional coverage and assessment through well crafted assignments even when they do not necessarily fit into a course (Table 6, CENG 4339 Assignment for Outcome 11 Social Sciences).

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Appendix I - CIVIL ENGINEERING BODY OF KNOWLEDGE FOR THE 21ST CENTURY, Table 1. Entry into the practice of civil engineering at the professional level requires fulfilling 24 outcomes to the various levels of achievement.⁵

Key: L1 through L6 refers to these levels of achievement:

Level 1 (L1) - Knowledge

Level 2 (L2) - Comprehension

Level 3 (L3) - Application

Level 4 (L4) - Analysis

Level 5 (L5) - Synthesis

Level 6 (L6) - Evaluation

Outcome number and title	To enter the practice of civil engineering at the professional level, an individual must be able to demonstrate this level of achievement.
<i>Foundational Outcomes</i>	
1 Mathematics	<i>Solve</i> problems in mathematics through differential equations and <i>apply</i> this knowledge to the solution of engineering problems. (L3)
2 Natural sciences	<i>Solve</i> problems in calculus-based physics, chemistry, and one additional area of natural science and <i>apply</i> this knowledge to the solution of engineering problems. (L3)
3 Humanities	<i>Demonstrate</i> the importance of the humanities in the professional practice of engineering (L3)
4 Social sciences	<i>Demonstrate</i> the incorporation of social sciences knowledge into the professional practice of engineering. (L3)
<i>Technical Outcomes</i>	
5 Materials science	<i>Use</i> knowledge of materials science to <i>solve</i> problems appropriate to civil engineering. (L3)
6 Mechanics	<i>Analyze</i> and solve problems in solid and fluid mechanics. (L4)
7 Experiments	<i>Specify</i> an experiment to meet a need, conduct the experiment, and analyze and <i>explain</i> the resulting data. (L5)
8 Problem recognition and solving	<i>Formulate</i> and solve an ill-defined engineering problem appropriate to civil engineering by <i>selecting</i> and applying appropriate techniques and tools. (L4)
9 Design	<i>Evaluate</i> the design of a complex system, component, or process and <i>assess</i> compliance with customary standards of practice, user's and project's needs, and relevant constraints. (L6)
10 Sustainability	<i>Analyze</i> systems of engineered works, whether traditional or emergent, for sustainable performance (L4)
11 Contemporary issues and	<i>Analyze</i> the impact of historical and contemporary issues on the identification, formulation, and solution of

historical perspectives	engineering problems and <i>analyze</i> the impact of engineering solutions on the economy, environment, political landscape, and society. (L4)
12 Risk and uncertainty	<i>Analyze</i> the loading and capacity, and the effects of their respective uncertainties, for a well-defined design and <i>illustrate</i> the underlying probability of failure (or nonperformance) for a specified failure mode. (L4)
13 Project management	<i>Formulate</i> documents to be incorporated into the project plan. (L4)
14 Breadth in civil engineering areas	<i>Analyze</i> and solve well-defined engineering problems in at least four technical areas appropriate to civil engineering. (L4)
15 Technical specialization	<i>Evaluate</i> the design of a complex system or process, or <i>evaluate</i> the validity of newly created knowledge or technologies in a traditional or emerging advanced specialized technical area appropriate to civil engineering. (L6)
<i>Professional Outcomes</i>	
16 Communication	<i>Plan, compose, and integrate</i> the verbal, written, virtual, and graphical communication of a project to technical and non-technical audiences. (L5)
17 Public policy	<i>Apply</i> public policy process techniques to simple public policy problems related to civil engineering works. (L3)
18 Business and public administration	<i>Apply</i> business and public administration concepts and processes. (L3)
19 Globalization	<i>Analyze</i> engineering works and services in order to function at a basic level in a global context. (L4)
20 Leadership	<i>Organize and direct</i> the efforts of a group. (L4)
21 Teamwork	<i>Function</i> effectively as a member of a multidisciplinary team. (L4)
22 Attitudes	<i>Demonstrate</i> attitudes supportive of the professional practice of civil engineering. (L3)
23 Lifelong learning	<i>Plan and execute</i> the acquisition of required expertise appropriate for professional practice. (L5)
24 Professional and ethical responsibility	<i>Justify</i> a solution to an engineering problem based on professional and ethical standards and <i>assess</i> personal professional and ethical development. (L6)