Adopting the BOK2 Student Outcomes: A Six-Year Retrospective

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Abstract

In 2008, the American Society of Civil Engineers (ASCE) published the Civil Engineering Body of Knowledge, Second Edition (BOK2), reflecting ASCE's vision of the skills and knowledge the next generation of civil engineers must acquire. The Department of Civil Engineering at Lawrence Technological University adopted the BOK2 that same year as part of its regular program review process. Faculty engaged in extensive debate on the prudence of adopting a new, more complex standard just two years before the ABET accreditation visit in 2010. However, the Department's commitment to continuous improvement was the eventual impetus for adoption of the BOK2 student outcomes for our program. This paper provides an overview of the challenges faced and the various approaches taken by faculty to integrate the BOK2 outcomes into the civil engineering curriculum. The paper also documents the successful ABET review in 2010 in which the program was granted full accreditation and the maximum six-year review cycle. Finally, after six years of the Department functioning with BOK2 as student outcomes, the faculty can reflect and comment upon the successful and more the problematic aspects of the experience.

I. Introduction

A. Overview of the Department of Civil Engineering

Lawrence Technological University is located in Southfield Michigan. There are approximately 120 students in the undergraduate program. The Department employs seven full-time faculty members, covering six of the subdisciplines. In a given semester approximately four to six adjuncts will serve as instructors for the undergraduate program.

To graduate, students are required to pass at least one course in each of the recognized civil engineering subdisciplines: environmental, construction, structural, transportation, water resources, geotechnical and surveying. Students may then specialize in one or more of the subdisciplines by enrolling in several available electives. To complete their education, students participate in a two-course capstone design sequence during their senior year.

B. Overview of BOK2

The American Society of Civil Engineers (ASCE), when it published *Policy Statement 465 (PS 465), Academic Prerequisites for Licensure and Professional Practice*[i], committed itself to creating a body of knowledge (BOK). Among other things, the BOK would address the suggested requirements for a baccalaureate degree in civil engineering. ASCE encouraged institutions to support and implement the BOK. Implementation of PS 465 commenced in earnest with the publishing of the initial Body of Knowledge (BOK1) in 2004. Almost immediately a committee was formed to address input from various stakeholders by creating a second edition (BOK2).[ii]

The content of the BOK2 was also influenced by the *ABET Criteria for Accrediting Engineering Programs*, which includes the Program *Criteria for Civil and Similarly Named Engineering Programs*. The ABET criteria covers generic engineering outcomes, such as "an ability to identify, formulate, and solve engineering problems," and also civil engineering specific outcomes, such as "apply knowledge of four technical areas appropriate to civil engineering."[iii]

The BOK2 Outcomes, as adopted by the Department of Civil Engineering at Lawrence Technological University, are attached as Appendix A.

II. Adoption of BOK2 Outcomes

In 2004 the Department, in conjunction with the review of its Program Educational Objectives, published its revised Student Outcomes, as set forth below:

The Civil Engineering Department at Lawrence Technological University will offer a program in which our graduates have:

- *(a) an ability to apply knowledge and principles of mathematics, science, and engineering in the solution of civil engineering problems*
- *(b) an ability to design and conduct experiments, as well as to analyze data and interpret results*
- *(c) an ability to design a civil engineering system, component, or process to meet desired project needs*
- *(d) an ability to function on multi-disciplinary teams including participation in a senior-level design project sequence*
- *(e) an ability to identify, formulate, analyze, and solve engineering problems*
- *(f) an understanding and appreciation of all aspects of professionalism including ethical responsibility, participation in professional organizations, and service*
- *(g) an ability to communicate effectively developed through report writing and in-class presentations*
- *(h) the broad education necessary to understand the impact of engineering solutions in a global, sustainable, 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*
- *(l) an ability to apply the fundamentals of civil engineering to the analysis of an existing project component*
- *(m) an understanding of the benefits of passing the FE exam and becoming a licensed professional*

The framework for the Department outcomes was borrowed from the familiar ABET (a)-(k) student outcome criteria. Based on input from various program stakeholders, such as faculty, the Civil Engineering Advisory Board (Advisory Board) and program alumni, the Department built on this framework to create outcomes that were geared more towards a contemporary civil engineering curriculum.

While a few of the ABET outcomes were adopted with their original wording, most were revised to one extent or another. For example, to make the outcomes less generic, the term "civil engineering" was inserted in (a) and (c). More subtle revisions were also made: in (b), "results" was used in lieu of "data"; in (h), "sustainable" was substituted for "economic." Based on significant constituent input, the Department adopted two additional outcomes: (l) was created to again place more emphasis on the civil engineering discipline, rather than generic engineering, and (m) was an acknowledgement of the importance of professional licensure.

Early in 2008, during the regularly scheduled programmatic review, faculty decided to adopt the BOK2 Outcomes with some concerns based on a pending 2010 ABET cycle. The concern was three-pronged: the first two prongs were generally internal considerations, while the third prong was external to the Department.

1. *Could the Department fully implement the BOK2 in the available time frame, with sufficient thoroughness to improve the curriculum?* Under normal circumstances, engineering faculty have a multitude of responsibilities with respect to their courses, research and university service. Adding the adoption of BOK2, which almost doubles the number of program outcomes previously reviewed, seemed a daunting task.

2. *Could the Department implement the BOK2 with sufficient understanding and thoroughness to satisfy ABET criteria?* Even in perfect situations, most civil engineering departments would be overcome with trepidation when preparing for an ABET accreditation visit. The faculty's uneasiness was magnified at the thought of attempting to satisfy ABET criteria with freshly adapted student outcomes.

3. *Would the ABET evaluator be knowledgeable on BOK2?* Since the BOK2 was so recently published, there was a distinct possibility that ABET may not have an evaluator knowledgeable on the BOK2, much less experienced at reviewing programs employing the BOK2. Like a newly passed law that has not been tested in court, the BOK2 would likely not have been invoked more than a few times, if at all. Moreover, extending the simile, an untested law is susceptible to varying interpretations, as well might the BOK2 outcomes.

Faculty recognized that it had varying degrees of control over the answers. For numbers one and two, the response simply was to do whatever it took to make it happen; full commitment was required by each member. Question number two, however, was still somewhat subject to evaluator interpretation. Faculty believed, however, the adoption of BOK2 demonstrated continuous improvement, and as such would trump any perceived weakness in fully satisfying all outcomes.

Question number three was recognized as the consideration most out of the Department's control. There was no guarantee that any particular evaluator would have extensive knowledge of the BOK2. Thus, the only way to mitigate this potential circumstance was to request an evaluator who had the requisite experience. If no such evaluator existed, the faculty was resigned to having to educate the evaluator on all salient aspects of BOK2. As it turned out, we

were assigned an evaluator with functional knowledge of the BOK2 and was supportive of our efforts to "Raise the Bar".

B. Revision of Civil Engineering Program Educational Objectives and Student Outcomes

The Department assessment plan requires review of the program educational objectives (PEOs) every three years. In general, the review process commences with faculty who suggest changes if necessary. At the annual meeting of the Advisory Board, the proposed PEOs with supporting Student Outcomes are presented for comment and suggestions. Based on the Board's response, revised PEOs are then disseminated for further consideration. Another layer of review is added when comments are solicited from recent civil engineering alumni. Faculty reviews any potential additional revisions, puts the PEOs into final form and publishes them electronically.

After several rounds of discussions and proposed revisions, the faculty generated draft PEOs and submitted them for Board consideration. The final version of the most recent PEOs set forth below are the result of the complete review process:

The objectives of the Department of Civil Engineering are to offer a program that:

- *provides a strong foundation in mathematics, natural sciences, humanities and social sciences as a basis for developing into a well-rounded engineer;*
- *provides an essential understanding of the fundamental principles of engineering;*
- *develops the ability to identify and analyze problems with realistic constraints, devise and critique engineering alternatives, and formulate solutions both individually, as well as in a team environment;*
- *allows for the application contemporary skills for the solution of civil engineering problems, as well as the application and integration of the project management process;*
- *develops effective communicators in engineering and business environments and encourages positive contributions to all levels of public policy decision-making; and*
- *stresses professionalism, leadership and committing to professional development through life-long learning and licensure; and encourages community and professional service, and the need to act ethically in all matters.*

Virtually all the revisions to the PEOs have their genesis in the BOK2. Indeed, several outcomes are specifically cited, while action verbs—a primary element of Bloom's Taxonomy—are utilized to describe the learning path to the outcome. For example, the first bullet was updated to directly list the foundational outcomes covered in BOK2. The third bullet connotes the abilities needed to apply critical thinking, while employing the classic Bloom's action verbs: identifying, analyzing and proposing solutions to real-life engineering problems.

The fifth bullet initially addresses communication, an important component of the program outcomes. Public policy, which is a new outcome, is then denoted. The last bullet is somewhat of a catch-all, specifically mentioning three BOK2 outcomes, while hinting at a fourth: attitudes.

C. Review Process for Student Outcomes

Clearly, the adopting the BOK2 would trigger the need for an extensive review of the curriculum. The Student Outcome[1] Review Flowchart in Figure 1 was not generated prior to commencing the process in 2010. Rather, it evolved as the process evolved. Indeed, the simple boxes and straight lines suggest an easy path to implementation; in reality, the original review was relatively chaotic. An example of this evolution was the fact that the process unexpectedly became iterative. Often faculty assume that a particular subject was finalized, Additional questions would arise, however, requiring faculty to revisit the subject and debate previously covered topics.

As depicted in Figure 1, the initial tasks for student outcome review required the entire faculty to participate in the establishing of the appropriate achievement level for each outcome. Next, each outcome was mapped to one or more required courses. The decision diamond signifies the discussion and decision iteration for determining whether the current curriculum sufficiently addressed all the outcomes. To aid in this task, the faculty developed the Program Outcomes Coverage Matrix. The required courses component of the matrix is attached as Appendix B.

The next step in the process was for individual faculty members, in their capacity as course coordinators, to evaluate and, if necessary, revise course learning objectives (Figure 2) which are published as part of our Course Purpose Document (CPD). The CPDs are a program specific version of required ABET syllabi. To determine whether the appropriate outcome achievement levels for each course are attained, student learning is assessed. If the appropriate levels are not achieved, potential revisions to the courses are discussed and implemented. Even if the appropriate levels are attained, courses are still subject to a periodic curriculum evaluation and possible revision.

[1] Note: In accordance with ABET, these are referred to as Student Outcomes. Throughout our adoption of the BOK2 and ABET visit in 2010 they were Program Outcomes so that language is used in this manuscript.

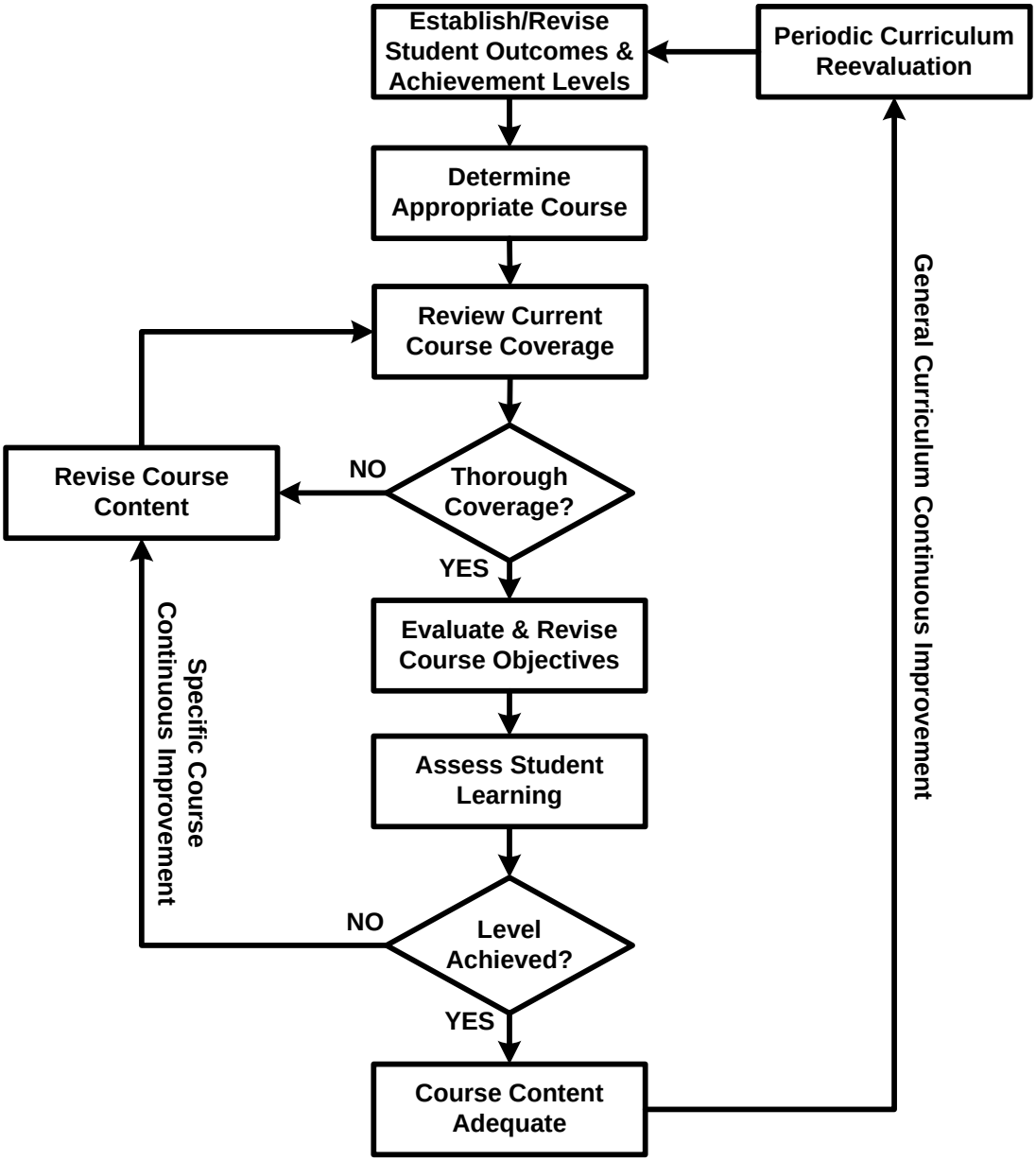

Figure 1 Outcome Review Process Flowchart

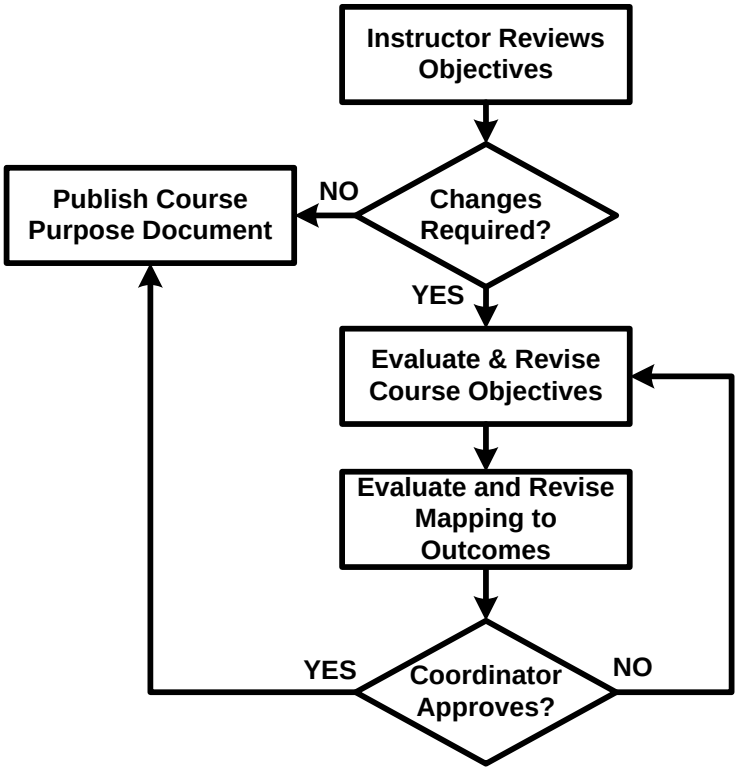

Figure 2:Course Purpose Document Review for Course Learning Objectives

III. Challenges

A. Educating Faculty

When the Department decided to adopt the BOK2 Outcomes, it was discovered that several faculty members had never been exposed to the BOK1 much less BOK2. Therefore, the concept of a professional body of knowledge was unknown to them. Consequently, a significant amount of time was dedicated to general discussions with respect to the intent of the BOK2. The conversation began with each faculty member being provided a copy of the BOK2 book and asked to read/review its contents.

Eventually the faculty developed an understanding of BOK2 sufficient to agree to embark on full implementation. Admittedly, a deeper appreciation for the concept of a body of knowledge did not develop until the outcome review process was well underway. It was then that faculty members began to understand the depth and importance of the BOK2.

Several faculty members were only vaguely aware of Bloom's Taxonomy, which serves as the underpinning for the descriptions of the outcomes. Remedial discussions were held on Bloom's, and how the levels of cognitive achievement fit into the BOK2 equation. While the faculty developed an understanding of Bloom's, intense discussions still occur with respect to competing interpretations of various terms. For example, what constitutes design at various Bloom's level was vigorously debated.

Because the civil engineering program caters to both day and night students, it is usually necessary to employ several industry practitioners as adjunct professors. The Department hosted evening meetings with the adjuncts to, among other things, update them on ABET accreditation preparations and to acquaint them with the BOK2. The attendees were bombarded with terms that, while they were well known in academia, they were relatively unfamiliar in industry. Terms such as assessment, student outcomes, ABET criteria and BOK2 required defining and discussion.

Even though some adjuncts had served as instructors in the Department for several years, and were knowledgeable about concepts such as course learning objectives, there was still confusion. There was little understanding as to the connection between course learning objectives and student outcomes. Moreover, the adjuncts were conflating ABET requirements with BOK2 Outcomes. It became evident that the Department assessment coordinator should meet with each adjunct individually to discuss the BOK2, with special emphasis on explaining the new program outcomes, how they should translate into course objectives, and at what level of achievement their students should have upon course completion.

B. Setting Levels of Achievement & Curriculum Coverage

The BOK2 sets forth a recommended achievement level for each outcome at the baccalaureate stage. It is apparent a significant amount of thought by the BOK Committee went into the level determination. Regardless, the levels for most outcomes were subjected to spirited debate by faculty members. The first question by faculty would always be whether the current civil engineering curriculum would support higher levels than those recommended in BOK2.

The most contentious and prolonged debates revolved around the subtle differences between various action verbs in Bloom's Taxonomy. For example, is there any substantive difference between *solving* a problem and *analyzing* and *solving* a problem? One professor might see no appreciable difference—after all, doesn't an engineer need to analyze a problem before solving it? Another professor might respond that there is a substantial difference; real analysis is definitely at a higher level.

Each outcome was discussed thoroughly, and, with a few exceptions, most of the recommended levels of achievement were accepted by faculty. Outcome 7: Experiments was discussed at length and faculty decided that the curriculum went beyond *analysis* and into *synthesis*. Outcome 16: Communication was similarly dealt with. The BOK2 recommendation was a level 4, analysis: "Organize and deliver effective…communications." After much discussion, faculty determined that the curriculum reached level 5, synthesis: "Plan, compose and integrate… communication." The three other outcomes where a higher level of Bloom's was implemented were Outcome 13: Project Management, Outcome 15: Technical Specialization, and Outcome 23: Lifelong Learning.

The faculty did determine that the current curriculum could not meet Outcome 19: Globalization, which requires students to solve engineering problems with a global context. None of the existing courses focused on global engineering problems as described in the BOK2. Faculty

decided that level 2, comprehension, was sufficient, as opposed to level 3, application, given our PEOs.

C. Confirming Course Coverage of Outcomes

Significant and lengthy debates occurred over the issue of course coverage of outcomes. It took several meetings before the creation of the initial draft of the coverage matrix (see Appendix B). The changes ran the gamut from simple rewording of course learning objectives documented in the Course Purpose Documents to promoting an elective course to a required course to ensure student attainment.

For example, except for Outcome 14: Breadth in Civil Engineering Areas and Outcome 15: Technical Specialization, the BOK2 does not require reaching the highest achievement level in more than one course. However, the faculty determined it was prudent to introduce redundancy into the system by meeting the highest levels of each outcome in at least two courses. In the event the appropriate level of achievement was not attained for a particular outcome in one course, the student may have attained the required level in a second course (Figure 3).

Outcome 14: Breadth and Outcome 15: Technical Specialization are characterized in BOK2 as the final two technical outcomes. These are differentiated from the other twenty-two in that both must be analyzed and applied on a broader curriculum-wide basis. If a course is designated by our program as a terminal course (i.e. top tier) on one of the subdiscipline tracks used to satisfy outcome requirements, than the course must satisfy both outcomes at their highest levels of achievement as defined by the program (Level 4 for Outcome 14 and Level 3 for Outcome 15). For example, ECE4544 Hydraulic Engineering is designated as top tier course. Thus, as depicted in Figure 3, it is a terminal course for the water resources subdiscipline track. The content of Hydraulic Engineering must therefore allow the student to attain the highest levels of achievement in Outcome 14: Breadth in Civil Engineering Areas and Outcome 15: Technical Specialization.

When analyzing a course such as ECE4563 Hydrology, outcomes are considered at two levels. At the course level, outcomes are directly addressed through course content. For example, Outcome: Problem Solving and Outcome 9: Design are mapped to the course objective associated with hydrologic reservoir routing to predict outflow hydrographs associated with storage design. This analysis is generally performed by the course coordinator, who likely does not need to discuss the mapping with other faculty members.

The second level of analysis is at the curriculum level. For example, ECE4563 Hydrology is also designated by the program as top tier course in a civil engineering undergraduate program subdiscipline track (Figure 3). Therefore, the entire faculty is involved in discussing top tier courses to make sure content results in the highest levels of achievement in Outcome 14: Breadth in Civil Engineering Areas and Outcome 15: Technical Specialization.

Although it was commendable to attain high achievement levels in elective courses (such as ECE4563 Hydrology), to satisfy ABET requirements the Department needed to guarantee that all

students would attain all outcomes. No such guaranteed could be given if the Department relied on electives for certain outcomes.

As mentioned above, most of the outcomes were covered through moderate revision of course learning objectives; however, adoption of the BOK2 dictated more substantial changes to specific courses or some reliance on courses outside of the civil engineering curriculum for coverage. Courses that needed specific modification include the following:

LDR2001 Leadership Principles and Practices

The University has a mandatory leadership curriculum where LDR2001 is a foundational course. This course provides adequate coverage for Outcome 10: Leadership but it had to be assessed at the civil engineering level and its objectives mapped to Bloom's taxonomy. The Civil Engineering Department coordinates direct assessment with the Leadership Curriculum Coordinator who was very helpful in this process.

MCS3403 Probability and Statistics

MCS3403 has been a required course in the Civil Engineering curriculum since 1998, but Outcome 12: Risk and Uncertainty required moderate revisions to this course. Civil Engineering faculty met with the Math and Computer Science Department and they agreed to revise course learning objectives to address Outcome 12 and incorporate Bloom's taxonomy into course objectives. Part of the process included the adoption of a new book specifically geared to engineering applications (*Probability and Statistics for Engineers and Scientists*[iv]) and assessment conducted in conjunction with the Civil Engineering Department similar to LDR2001.

ECE4051 Ethics and Professional Issues

This course has been a required course in the civil engineering curriculum for approximately 20 years but the course objectives were modified to address the professional outcomes of the BOK2 including Outcome 3: Humanities, Outcome 11: Historical and Contemporary Issues, Outcome 22: Attitude, Outcome 23: Lifelong Learning, and Outcome 24: Ethical and Professional Responsibilities. In addition, since 2006 the course is taught in a hybrid approach with approximately 50% of the course material covered online or though self-directed learning[v]. The course has been proven effective at addressing and reinforcing a significant number of the professional program student outcomes. In addition, offering the course in a hybrid e-Learning environment has enhanced both the breadth and depth of coverage of the course objectives, which are related to the program outcomes. This is particularly helpful in addressing the professional outcomes on lifelong learning, contemporary issues, and professional attitudes. Finally, the course serves as a direct assessment vehicle for the professional outcomes. As such, this course can serve as a model for other institutions that are trying to cover additional BOK2 outcomes in a typically packed technical curriculum.

ECE4243 Civil Engineering Management Practices

By establishing Outcome 13: Project Management, the BOK2 underscored the importance of construction engineering as a subdiscipline. Consequently, faculty determined that the Program should make CE Management Practices, a project management based course, a requirement in the curriculum. Additionally, it would be considered as a terminal course on the construction engineering subdiscipline track.

Elevation of CE Management Practices to top tier status requires students attain the highest levels of the Breadth in Civil Engineering and Technical Specialization outcomes. While the Breadth outcome was inherently satisfied by offering a construction engineering-based course within the curriculum, minor revisions in the course content were effected to address Technical Specialization.

CE Management Practices also provides a platform for reaching the highest achievement levels in other professional outcomes that are generally not addressed in the design based courses, such as Outcome 17: Public Policy and Outcome 18: Business and Public Administration.

ECE4021 and 4033 Civil Engineering Senior Design I and II

Obviously, a capstone sequence is required of all civil engineering programs but our sequence was modified to insure redundant BOK2 Outcome coverage at the highest Bloom's level by introducing requirements for Outcome 9: Design, Outcome 10: Sustainability, Outcome 13: Project Management, and Outcome 16 Communication. Finally, professional mentors and improved rubrics were added to the course which assists with direct assessment of BOK2 outcomes.

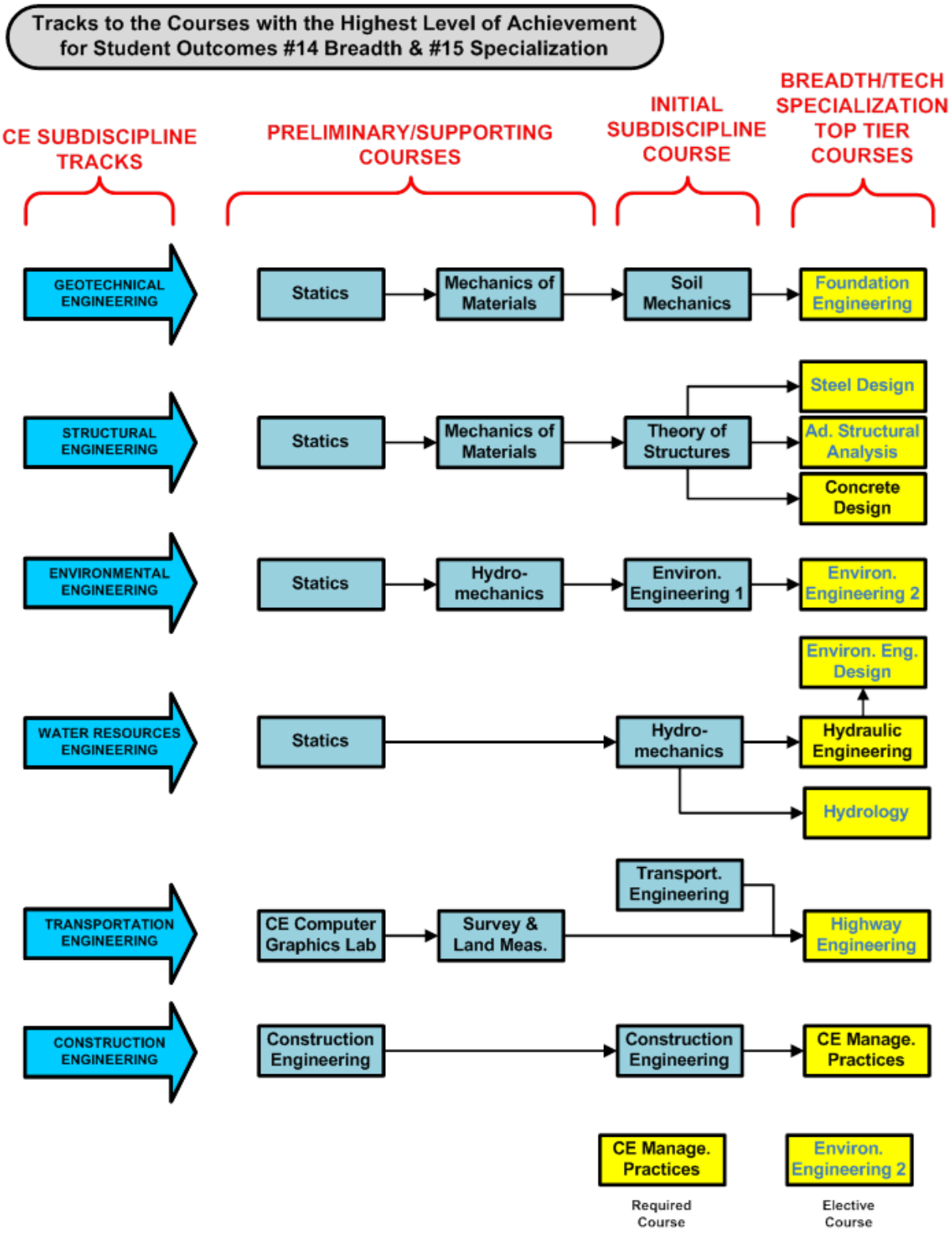

Figure 3: Breadth and Technical Specialization Coverage

IV. ABET

In 2010, the Civil Engineering Department submitted for ABET accreditation. In addition to the normal ABET procedures, one of our first tasks was to demonstrate to the program evaluator that our program outcomes (based on the BOK2) would meet/exceed the ABET outcomes. Figure 4, demonstrates the linkage between the two outcomes.

Civil Engineering Program	ABET Outcomes
1. Mathematics	(a) Mathematics, science, engineering
2. Natural Sciences	(a) Mathematics, science, engineering
3. Humanities	EAC/ABET Criterion 5 (general education component)
4. Social Sciences	
5. Materials Science	(a) Mathematics, science, engineering
6. Mechanics	(a) Mathematics, science, engineering
7. Experiments	(b) Experiments
8. Problem Recognition and Solving	(e) Engineering problems
9. Design	(c) Design
10. Sustainability	(c) Design
11. Contemporary Issues and Historical Perspectives	h. Impact of engineering j. Contemporary issues
12. Risk and Uncertainty	
13. Project Management	Program Criteria for Similarly Named Engineering Programs
14. Breadth in Civil Engineering Areas	Program Criteria for Similarly Named Engineering Programs
15. Technical Specialization	
16. Communication	(g) Communication
17. Public Policy	
18. Business and Public Administration	
19. Globalization	(j) Contemporary issues
20. Leadership	Program Criteria for Similarly Named Engineering Programs
21. Teamwork	(d) Multidisciplinary teams
22. Attitudes	
23. Lifelong Learning	(i) Lifelong Learning
24. Professional and Ethical Responsibility	(f) Professional and Ethical Responsibility

Figure 4: Mapping between BOK2 and ABET student outcomes (adapted from BOK2)

The Department employs a robust multi-tool assessment plan which includes direct and indirect assessment of student learning. Prior to adoption of the BOK2 Outcomes, a relatively straightforward process existed to document student learning. Student work was collected in senior level courses on a rotating basis, such that not every course was assessed every semester. A faculty subcommittee would assign a numeric score for each outcome, based on a five-point scale: a “1” indicated “no demonstration” and a “5” indicated “advanced demonstration.”

Upon adoption of the BOK2, the process became much more difficult to implement, track and assess. The additional outcomes required the faculty to collect a larger volume of student work for evaluation. While the larger volume was anticipated, there were some unanticipated problems.

Adopting the BOK2 dictated the sampling of a greater number of courses to verify student achievement (see Appendix B) at the highest level of Bloom's taxonomy, necessitating the collection and evaluation of significantly more work. Furthermore, the scoring became problematic because the assigned numeric scores (1 to 5 on a five point scale) were confused with the Bloom's Taxonomy designations for the levels of achievement. For example, a course could show advanced demonstration of an outcome (score of 5 on the rubric) for an objective that is level 3 in Bloom's taxonomy. However, early in the process faculty occasionally would assign a level of Bloom's instead of the level of demonstrated achievement of the objective.

Finally, the Department recognized the need for improved tools to properly assess and score student work as it related to the BOK2 Outcomes. Examples include the revised writing and presentation rubrics employed in the senior capstone sequence. BOK2 language, including descriptions of the levels of achievement, were utilized in the development of the rubrics, which greatly assisted with communicating course expectations to students.

Based on the demonstrated linkage (Figure 4) and the assessment tools and techniques, the program was awarded a full six year accreditation cycle. The ABET final program statement includes the following comments by the program evaluator which serves as a testament to our adoption of the BOK2:

"The program has incorporated the ASCE Body of Knowledge into their program outcomes. This demonstrates a desire to be on the leading edge of engineering education practices."

"The students are enthusiastic about and very satisfied with the civil engineering program. They greatly appreciate the small class sizes, easy access to faculty, and the practical expertise offered by the faculty."

V. Conclusion

Implementing the BOK2 outcomes as a program's student outcomes is an arduous and time-consuming task but one that is very worthwhile as programs seek to prepare their students for the future of civil engineering. The goal of this paper was to forewarn of the numerous potential pitfalls civil engineering programs must consider when discussing whether to adopt the BOK2 and to offer some practical suggestions to ease implementation.

As demonstrated in Figure 1 and the accompanying discussion, full implementation required the faculty to participate in an iterative process. Probably the main reason the Department was able to move forward was that each faculty member bought into the implementation. Without this commitment to continuous improvement, the process would have been even more painful, possibly interfering with teaching operations, as well as jeopardizing the effort to achieve full accreditation.

That is not to say that all tasks are 100% complete. Examples of unresolved issues include the need to further consider how best to address Outcome 12: Risk and Uncertainty in design courses, and whether the achievement level chosen for Outcome 15: Technical Specialization is appropriate for an undergraduate program. The ongoing iterative process of assessment and evaluation, dictated by continuous improvement, will undoubtedly reveal the need for additional adjustments to the curriculum.

The BOK2 addresses different aspects of its relevance to various civil engineering stakeholders, including faculty:

> "[A]ssists civil engineering and other faculty in designing curricula, creating and improving courses, and teaching and counseling students."

Appendix A
Department of Civil Engineering
Student Outcomes

Outcome Number and Title	To graduate with a B.S. Degree in Civil Engineering from _____University and enter the practice of civil engineering, the student must demonstrate competence in each of 24 Program Outcomes.
Foundational Outcomes	
1 Mathematics	***Solve*** problems in mathematics through differential equations and ***apply*** this knowledge to the solution of engineering problems.
2 Natural Sciences	***Solve*** problems in calculus-based physics, chemistry and geology, and ***apply*** this knowledge to the solution of engineering problems.
3 Humanities	***Demonstrate*** the importance of the humanities in the professional practice of engineering.
4 Social Sciences	***Demonstrate*** the incorporation of social sciences knowledge into the professional practice of engineering.
Technical Outcomes	
5 Materials Science	**Use** knowledge of materials science to ***solve*** problems appropriate to civil engineering.
6 Mechanics	**Analyze** and solve problems in solid and fluid mechanics.
7 Experiments	***Specify*** and ***design*** an experiment to meet a specified need; conduct the experiment and analyze, interpret and ***explain*** the resulting data.
8 Problem Recognition and Solving	***Develop*** problem statements and solve both well-defined and open-ended civil engineering problems by ***selecting*** and applying appropriate techniques and tools.
9 Design	***Design*** a system or process to meet desired needs within such realistic constraints as economic, environmental, social, political, ethical, health and safety, constructability and sustainability.
10 Sustainability	***Apply*** the principles of sustainability to the design of traditional and emergent engineering systems and ***explain*** how civil engineers should strive to comply with the principles of sustainable development in the performance of their professional duties.
11 Contemporary Issues and Historical Perspectives	***Explain*** the impact of historical and contemporary issues on the identification and formulation of solutions to engineering problems, and ***explain*** the impact of engineering solutions on the economy, environment, political landscape and society.
12 Risk and Uncertainty	***Apply*** the principles of probability and statistics and solve problems containing uncertainty.
13 Project Management	***Analyze*** a proposed project and ***formulate*** documents for incorporation into the project management plan.

14 Breadth in Civil Engineering Areas	***Analyze*** and solve well-defined engineering problems in at least four technical areas appropriate to civil engineering.
15 Technical Specialization	***Apply*** specialized tools or technologies to solve problems in traditional or emerging specialized technical areas of civil engineering.
Professional Outcomes	
16 Communication	***Plan, compose*** and ***integrate*** the verbal, written, virtual and graphical communication of a project to technical and non-technical audiences.
17 Public Policy	***Discuss*** and ***explain*** key concepts and processes involved in public policy.
18 Business and Public Administration	***Explain*** key concepts and processes used in business and public administration.
19 Globalization	***Explain*** global issues related to professional practice, infrastructure, environment and service populations as such issues arise across cultures and countries.
20 Leadership	***Explain*** leadership principles and attitudes and ***apply*** those principles and attitudes when making decisions and directing the efforts of a small group.
21 Teamwork	***Function*** effectively as a member of an intra-disciplinary team and ***evaluate*** the performance of the team and individual team members.
22 Attitudes	***Explain*** attitudes supportive of the professional practice of civil engineering.
23 Lifelong Learning	***Demonstrate*** the ability for self-directed learning and ***identify*** additional knowledge, skills and attitudes appropriate for continued professional practice.
24 Professional and Ethical Responsibility	***Explain*** the many aspects of professionalism and what it means to be a member of the civil engineering profession; ***analyze*** a situation involving multiple conflicting professional and ethical interests to determine an appropriate course of action.

Appendix B
Department of Civil Engineering
Student Outcomes Coverage Matrix

Foundational Outcomes					Technical Outcomes											Professional Outcomes								
Course	**Math (1)**	**Natural Science (2)**	**Humanities (3)**	**Social Sciences (4)**	**Material Science (5)**	**Mechanics (6)**	**Experiments (7)**	**Problem Solving (8)**	**Design (9)**	**Sustainability (10)**	**Cont. Issues & Historical (11)**	**Risk & Uncertainty (12)**	**Project Management (13)**	**Breadth (14)**	**Technical Specialization (15)**	**Communication (16)**	**Public Policy (17)**	**Business & Public Admin. (18)**	**Globalization (19)**	**Leadership (20)**	**Teamwork (21)**	**Attitudes (22)**	**Lifelong Learning (23)**	**Prof. and Ethical Responsibility (24)**
1012	3		2	2	2			3	3	2	2			2	2	4					3	2		3
1013	3						4	3			2			4		3					3			
1101								2							2									
1102	3							2				1												
1413		1			3	2	3	3	3		1	1		3	1	4					3			2
LDR2001																				3		3		
MCS3403												3												
3013	3	3			1	3		3	3					3		4								
3213					1	1			2				2	2		3	2	2						
3324	3	1					3	3	3		2			4		4	1							
3424	2	1			3	3	5	3	1			1		3	2	4					3			
3523	3					3		3						3										
3723	3	3				4		3	4					3										4
3823	3			3			3	3	2		3		2	4		4	2	2		2	2		3	4
4021				3	3	3		3	4	3		2	3	4	2	4	2	2		3	3	2	4	
4033				3	3	3		3	5	3		2	4	4	3	5	2	2		3	3	2	4	
4051			3							2	3					4	2		2	2		2	4	4
4243								4		2		2	4	4	3	5	2	2	2					
4544	3	3				4	5	4	4	3	3	3		4	3	4					3			
4743	3				2	3		3	4			1		4	1	5								4
4761	3					4	5		4			3		4		4					3			
Required Level of Achieve.	**L3**	**L3**	**L3**	**L3**	**L3**	**L4**	**L5**	**L4**	**L5**	**L3**	**L3**	**L3**	**L4**	**L4**	**L3**	**L5**	**L2**	**L2**	**L2**	**L3**	**L3**	**L2**	**L4**	**L4**

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