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Educating the Future Civil Engineer for the New Civil Engineering Body of Knowledge

Abstract
The purpose of this paper is to provide the engineering education community with its first formal update from ASCE's new Body of Knowledge (BOK) Educational Fulfillment Committee. Specific emphasis is given to survey data illustrating how well programs, in their current design, achieve the educational outcomes of both the first and second editions of the civil engineering BOK. The results of a curricular review by ten representative civil engineering programs are presented. Explanations are also presented as to why current curricula may fulfill or fall short of fulfilling specific BOK1 and BOK2 outcomes.

Introduction

The first edition of the *Civil Engineering Body of Knowledge for the 21st Century*[1] (BOK1), released in January 2004, has already impacted accreditation criteria and curricula and is changing how future civil engineers are educated. The second edition of the *Civil Engineering Body of Knowledge for the 21st Century*[2] (BOK2), released in February 2008, is also impacting programs and curricula and is motivating additional change in how future civil engineers are educated. Both the BOK1 and BOK2 express aspirational definitions of the knowledge, skills, and attitudes necessary for entry into the professional practice of civil engineering. The BOK1 consisted of 15 listed outcomes, including many with multiple topic areas presented as a single integrated outcome. The BOK2 is a comprehensive, coordinated list of 24 outcomes divided into three outcome categories: Foundational, Technical and Professional. Both the BOK1 and BOK2 outcomes have the desired level of achievement defined according to Bloom's Taxonomy for the cognitive domain[4]. Additionally, the BOK1 and BOK2 have recommended outcome achievement targets for each state of the fulfillment pathway: the baccalaureate degree (B), post-baccalaureate formal education (M/30), and pre-licensure experience (E).

To assess the impact of the BOK1 and BOK2 on civil engineering curricula and to facilitate broad adoption of the new BOK concepts in civil engineering education, the ASCE Committee on Academic Prerequisites for Professional Practice (CAP^3) established a new committee – the BOK Educational Fulfillment Committee (BOKEdFC) in late 2007. This new committee is charged with (1) fostering the creation of a learning community of scholars interested in engineering educational reform, (2) reviewing the work products of the Body of Knowledge Committee and providing feedback, and (3) documenting how programs can incorporate the Body of Knowledge into their curriculum. A key input to this work is the second edition of the *Civil Engineering Body of Knowledge for the 21st Century*[2].

The Civil Engineering Body of Knowledge – A Review

The first Body of Knowledge report[1] (BOK1) was published by ASCE in January 2004. Subsequent to the release of the January 2004 BOK1 report, the Curriculum Committee of CAP^3 recommended fundamental changes to the levels of achievement, reporting their findings in their committee report[3] dated December 2005. Their recommendations were supported by CAP^3 and subsequently adopted into the framework of BOK1 by ASCE. Thus, within this report, the acronym BOK1 refers to the January 2004 report with the December 2005 Curriculum Committee revisions.

A second Body of Knowledge committee was formed by CAP^3 in October 2005 and charged with producing a second edition of the BOK report in response to stakeholder input and additional changes in engineering education and practice. The 'refined' BOK report – or BOK2 – was adopted by ASCE and released to the community in February 2008.

One of the major contributions of the Curriculum Committee was a review of the educational development literature to find an appropriate framework that could link body of knowledge outcomes to actual learning and achievement. The committee's recommendation, as presented in the "Levels of Achievement Report" was to adopt Bloom's taxonomy, which is widely known and understood within the educational and engineering education communities.

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

The cognitive domain within Bloom's Taxonomy[4] has six defined levels of achievement (LOA):

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

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

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

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

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

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

The BOK1 and BOK2 Outcomes Rubric, developed using Bloom's Taxonomy, are graphically presented in Figures 1 and 2, respectively. These are simple graphical representations of the full rubrics, and the reader is directed to the Level of Achievement Report for the full BOK1 rubric and the BOK2 report for the full BOK2 rubric (which are available at www.asce.org/raisethebar). What is clearly represented in both figures is the recommended level of achievement that an individual must demonstrate for each outcome to enter the future practice of civil engineering at the professional level. Also, for each outcome, the portion of the level of achievement to be fulfilled through the bachelor's degree (B), the master's degree or equivalent (M/30), and pre-licensure experience (E). The focus of this paper is on assessing where our civil engineering

curricula are today with respect to providing content relative to those components of the BOK1 and BOK2 assigned to formal education, or the B and M/30.

Survey Description – Current Undergraduate Curricula Compared with BOK1 and BOK2
Most departments of civil engineering have already begun to modify their curricula for consistency with BOK1 – and some have begun to modify their curricula for BOK2. These modifications have been motivated by (1) decisions by those departments to embrace some or all of the recommendations of ASCE on the appropriate body of knowledge, or (2) the actual or anticipated changes to the ABET program criteria for civil engineering – or both. The BOK Educational Fulfillment Committee undertook an assessment of the extent to which current baccalaureate graduates are fulfilling the baccalaureate (B) component of the BOK1 and the BOK2. Members of the committee, representing a wide variety of institution[*], completed a survey assessing their own baccalaureate graduates with respect to fulfilling the level of achievement specified for each outcome contained in BOK1 and BOK2. Specifically, for each outcome in BOK1 and BOK2, each of the ten participating committee members estimated their baccalaureate graduates' fulfillment using the following scale:

3 = All of the outcome at this LOA is met by all of the baccalaureate graduates

2 = Most of the outcome at this LOA is met by all of the baccalaureate graduates

1 = Some of the outcome at this LOA is met by all of the baccalaureate graduates

0 = Little or none of the outcome at this LOA is met by all of the baccalaureate graduates

The scale is intentionally coarse because each committee member could not practically assess their students' fulfillment more accurately without a detailed assessment at each institution specifically targeted to this study. Even so, the committee agreed this coarse assessment would permit helpful judgment of the state of the programs surveyed with respect to BOK1 and BOK2. The following sections separately summarize the committee findings for programs' baccalaureate graduates fulfilling BOK1 and BOK2.

The survey results are graphically summarized in Tables 1A, 1B, 2A and 2B. Tables 1A and 1B are for BOK1 and 2A and 2B are for BOK2. The outcome numbers and titles are listed in the first and second columns, respectively, of each table. The remaining six columns are assigned to the six levels of achievement (LOA). Tables 1A and 2A show how many of the ten surveyed programs believe *all* of the outcome is fulfilled by *all* of their baccalaureate graduates for each level of achievement in BOK1 and BOK2, respectively. Tables 1B and 2B show how many of the ten programs believe *most or all* of the outcome is fulfilled by *all* of their baccalaureate graduates for each level of achievement. For example, for BOK1 Outcome 7 (Communication), Table 1A shows that seven of the ten surveyed programs believe *all* of the outcome is fulfilled by *all* of their baccalaureate graduates at LOA 4, but that only one of the ten surveyed programs believe *all* of the outcome is fulfilled by *all* their baccalaureate graduates at LOA 5. Similarly, Table 1B shows that six of the ten surveyed programs believe *most or all* of BOK1 Outcome 8 (Impact of Engineering) is fulfilled by *all* of their graduates at LOA 3, but that only two of the

[*] University of Alabama, University of Arkansas, Iowa State University, University of Louisiana-Lafayette, University of Montana, North Carolina State University, Northern Arizona University, Rose-Hulman University, University of Southern California, and Texas A&M University.

ten surveyed programs believe *most or all* of the outcome is fulfilled by *all* of their baccalaureate graduates at LOA 4. The "A" and "B" tables provide helpful comparison between 100% fulfillment and a slightly lower level of fulfillment that some assessment programs may consider to be sufficient for accreditation.

Tables 1A and 1B include additional information of interest to engineering program developers. For each of the 15 outcomes listed in these tables, one of the LOA has been annotated with double asterisks (**). The double asterisks identifies the LOA that the authors believe is dictated by the General Criteria for Baccalaureate Level Programs and the related Civil Engineering Program Criteria.[5] The authors' judgment is based upon their review and analysis of the *Commentary on the ABET Engineering Criteria for Civil and Similarly Named Program In the Context of the Civil Engineering Body of Knowledge (Version 3.4)*.[6] This analysis was reinforced by the authors' review of references [7], [8], and [9]. In the *Commentary (V3.4)*, the Accreditation Committee of CAP^3 has identified those baccalaureate-level LOA that are "beyond the criteria." These are LOA that, while needed for full and robust implementation of BOK1, cannot be required or enforced by an ABET program evaluator. In other words, the baccalaureate-level LOA's to the right of the double asterisk cells are beyond the scope of the current ABET baccalaureate-level general and program criteria. Outcome 12 (Technical Specialization) has no double asterisk entry since this outcome is intended to be fulfilled through masters-level formal education or equivalent.

As described earlier, the appropriate minimum level of achievement for the baccalaureate "B" level has been recommended by ASCE's Body of Knowledge Committee for each outcome in BOK1 and BOK2. This level is indicated by a bold black box around the appropriate "B" level LOA for each outcome. To assist with visualizing the results of the survey, for all levels of achievement at or below the "B" level, color coding has been provided in the tables to indicate how well baccalaureate graduates in the surveyed programs are fulfilling each LOA. Reproduction of the tables in black and white does not permit easy differentiation between red and green cells. White font has been assigned to the red cells to assist with this limitation. Green cells indicate baccalaureate graduates of 8 to 10 programs are believed to be fulfilling the LOA, yellow cells indicate graduate of 5-7 programs are fulfilling the LOA, and red cells indicate baccalaureate graduates of 4 or less programs are fulfilling the specified LOA. To further help with visualizing the results, the first column of each table corresponding to the outcome number has been similarly color coded consistent with the LOA corresponding to the "B" level for each outcome.

Analysis of Survey Results – Current Undergraduate Curricula versus BOK1

BOK1 sought to "raise the bar" with respect to expected knowledge, skills and attitudes of baccalaureate graduates and, ultimately, of those entering the professional practice of civil engineering. It is thus not surprising that the surveyed programs would identify some outcomes which are not being fulfilled at the "B" level for all of their baccalaureate graduates. This could be due to a number of factors. Some programs may have only begun to implement changes in their curricula so their graduates can fulfill the recommended LOA, so graduates may be still working towards that LOA. Other programs may have chosen up to now to only fulfill current lower or less prescriptive ABET criteria for some outcomes, and thus do not believe their graduates fulfill some or all of the BOK1 outcomes at the "B" level. In such cases, the BOK1

"B" level for those outcomes may not be fulfilled because departments have chosen not to do so, rather than because departments cannot do so. While this is a concern with respect to programs choosing to embrace BOK1, it is less troubling than Outcomes for which programs hope or profess to the "B" LOA, but for which they have been so far unsuccessful. More detailed comments on specific BOK1 outcomes are included in the following paragraphs of this section.

Outcome 2 (Experiments) is identified in both Tables 1A and 1B as being a BOK1 "B" level area of concern for the surveyed programs. Most of the surveyed programs agreed the area of concern for their program in Experiments at the "B" level, which is LOA 5 – Synthesis, is in the nature of their current civil engineering curricula. LOA5 for experiments specifies graduates "design a civil engineering experiment to meet a need; conduct the experiment, and analyze and interpret the resulting data." Most civil engineering baccalaureate programs do not strongly emphasize design of experiments, although most are generally strong at LOA4, which is the same as LOA5 but without *design* of experiments. Some programs have reported they are hopeful their graduates will be able to fulfill LOA5 by demonstrating design of a geotechnical investigation.

Table 1A identifies Outcome 3 (Design) as an outcome in which 4 or fewer programs believe *all* of the outcome "B" level – LOA 5 Synthesis - is fulfilled by all of their graduates. However, Table 1B indicates that all of the surveyed programs believe *most or all* of this outcome is fulfilled by their graduates at LOA 5. The area of concern in this outcome in Table 1A could be because Design at LOA 5 – Synthesis - is not easily fulfilled by all current civil engineering graduates, so the response could merely reflect that some programs are skeptical that all graduates have demonstrated an ability to design a complex system or process. The lower response for that outcome in Table 1A could also be a function of the rubric specified. The rubric identifies LOA5 - Synthesis as incorporating "realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability." Some of the surveyed programs may not expect graduates to consider more than one constraint in their designs. Thus, the graduates may be able to "design a complex system or process to meet desired needs," but not while incorporating multiple constraints of the types specified.

Outcome 8 (Impact of Engineering Solutions) is identified in Tables 1A and 1B as an area of concern in surveyed programs. The "B" LOA is level 3 which specifies "drawing upon a broad education, determine the global, economic, environmental, *and* societal impacts of a specific, relatively constrained engineering solution." This outcome is a good example of ASCE's "raise the bar" initiative. Programs focused on current ABET criteria may not typically address a similar outcome, particularly at the indicated LOA. For many programs, this outcome will require curricula modification to at least assess learning at LOA3, and perhaps to incorporate new learning in this outcome. Some surveyed programs reported LOA3 learning for this outcome, but the rubric use of "*and*" for the identified impacts, implying all four of the impacts, resulted in a lower response for their baccalaureate graduates' fulfillment.

Table 1A also identifies seven additional outcomes (4, 6, 7, 9, 10, 14 and 15) in which seven or less of the ten surveyed programs believe *all* of the outcome is fulfilled at the "B" LOA by all of their baccalaureate graduates. In general, the area of concern identified in some programs could be attributed to a program's choice not to fulfill the outcome at this time even if it is possible to do so, because changes have been implemented but not yet fulfilled, or because the program has not been able to practically implement the LOA for the outcome into their curricula. This is the

subject of further study by the committee at this time and will not be studied further in this report.

Examination of Tables 1A and 1B show that some programs' baccalaureate graduates fulfill outcomes at LOA higher than that expected. This is expected, as the BOK1 LOA are intended to define minimum levels of learning and many programs should be expected to exceed those levels. Of note is that most programs identified a relatively high LOA for Outcome 12 – Technical Specialization. It is possible that strengths in this or other outcomes could be correlated to areas of concern elsewhere in the same program, suggesting some imbalance within the curriculum. This is currently under further study.

Analysis of Survey Results – Current Undergraduate Curricula versus BOK2

The 'refined' body of knowledge presented in BOK2 reflects the BOK2 committee's attempt to add specificity and clarity to the original BOK (BOK1) and to address additional concepts described in reports of the National Academy of Engineering and other documents. The original 15 outcomes of the BOK1 were separated and expanded to 24 in BOK2, and organized into three categories: foundational, technical, and professional.

In some aspects, increasing the specificity of a given outcome allowed for a more direct assessment when committee members completed the self-assessment survey. Unsurprisingly, however, this specificity also revealed an increased number of areas of non-fulfillment in existing programs, as indicated in Tables 2A and 2B. In addition, the LOA indicated for baccalaureate programs, when applied to the increasingly-specific outcomes in BOK2, gives rise to fewer programs indicating "all" or "most" students achieving the outcome.

A prime example of specificity affecting self-assessed BOK fulfillment is indicated in outcomes associated with some of the foundational and professional practice outcomes – Humanities (BOK2 Outcome 3), Social Sciences (Outcome 4), Contemporary Issues/History (Outcome 11), Public Policy (Outcome 17), Business & Public Administration (Outcome 18), Globalization (Outcome 19), and Leadership (Outcome 20). In these cases Table 2A indicates that fewer than 5 programs – out of the 10 surveyed – indicated that "all" of their baccalaureate graduates fulfilled the outcome at the specified LOA. For the associated outcomes in BOK1 (Table 1A – Outcomes 8, 10, 14, 15), 5 or more programs indicated "all" students fulfilled the outcome at the specified LOA. One contributing factor to this difference relates to the specific nature of the outcome/LOA; for example, BOK2 Outcome 3 (Humanities) requires baccalaureate graduates to *demonstrate* the importance of humanities in the professional practice of engineering.

The observation related to the 'professional practice' outcomes provides evidence that the BOK – and particularly the BOK2 – has indeed "raised the bar" regarding the knowledge, skills, and attitudes required to enter professional practice.

An additional grouping of BOK2 outcomes in which fewer than 5 surveyed programs indicated "all" students fulfilled the outcome relates to those items which do not necessarily appear as discreet outcomes in either BOK1 or ABET criteria, including BOK2 Outcome 10 (Sustainability), and Outcome 12 (Risk & Uncertainty). It may also be argued that BOK2 Outcome 11 (Contemporary Issues/History) and Outcome 19 (Globalization) also have not

appeared *with the descriptions given in BOK2* in previous outcomes-based program assessment documents.

Interestingly, there does not appear to be any specific category of outcomes (i.e., Foundational, Technical, or Professional) in which all outcomes were identified as largely met or largely unmet. In each of the categories, the programs surveyed indicated "all" students fulfilling certain outcomes (and indicated "all" students did not fulfill certain outcomes) in a manner similar to that indicated previously. Thus, in all areas the BOK2 outcomes in which the programs included in this report self-identify as being largely unmet relate somewhat to topics which are relatively 'new' or are presented with a higher degree of specificity and/or higher level of achievement that has been suggested previously.

Self-identified program strengths – those BOK2 outcomes in which 8 or more of the 10 surveyed programs indicated that "all" students fulfill the specified LOA – track somewhat with the BOK1 results (and by extension, with traditional ABET program criteria). It is also interesting to note, as indicated in the BOK1 discussion previously, that many programs report "all" students fulfilling a higher LOA for Outcome 15 (Technical Specialization; see Table 2A) than is suggested by BOK2. There is another encouraging trend evident in Tables 2A and 2B. Recall that Table 2B represents the number of programs reporting either "all students meet all" of the outcome at the specified level of achievement, or "all students meet most" of the outcome at the specified level of achievement. In a number of instances (i.e. Outcomes 3, 4, 11, 12, 18 and 20) an outcome for which fewer than 5 surveyed programs reported "all" students fulfilled the outcome (Table 2A) at least 5 or more programs indicated that all students fulfilled "most" of the outcome (Table 2B). This suggests that programs have made substantive progress towards the fulfillment of the BOK2.

Survey Description – Current M/30 Curricula Compared with BOK1 and BOK2

The committee also undertook a preliminary assessment of the extent to which masters graduates are fulfilling the post-baccalaureate coursework (M/30) component of the BOK1 and the BOK2. The same committee members completed a survey similar to the earlier described baccalaureate survey assessing their own master-level graduates with respect to fulfilling the level of achievement specified for the few M/30 specified outcomes contained in BOK1 and BOK2. In terms of outcomes, this survey is very limited given the focus of the BOK1 and BOK2 on the baccalaureate as the primary strategy for fulfilling either body of knowledge.

Of the fifteen BOK1 outcomes, fourteen are assigned to the B and experience (E) stages of the fulfillment pathway. The M/30 is assigned to only one outcome, Outcome 12 (Specialized Area of Civil Engineering), with no expectation that this outcome is covered and achieved at the undergraduate level. The goal for BOK1 Outcome 12 is Bloom's Level 6 – Evaluation.

In contrast, three of the twenty-four BOK2 outcomes are mapped to master's level, while also incorporating attainment expectations at the B level. These three outcomes are Outcome 7 (Experiments; Level 5 – Synthesis), Outcome 8 (Problem Recognition and Problem Solving; Level 4 – Analysis), and Outcome 15 (Technical Specialization; Level 5 – Synthesis).

The ten participating programs were asked to identify the various types of master-level programs they offer. Five different graduate level pathways were identified: a master of science (MS)

with thesis, an MS without thesis but with a scholarly project, a master of engineering (MEng) with a scholarly project, an MEng with only coursework, and other options not listed. For each masters-level program offered, the ten programs were asked to assess the achievement level of their masters graduates relative to the respective BOK1 and BOK2 M/30 outcomes. The M/30 survey utilized the same course scale as the previous survey:

3 = All of the outcome at this LOA is met by all of the masters graduates

2 = Most of the outcome at this LOA is met by all of the masters graduates

1 = Some of the outcome at this LOA is met by all of the masters graduates

0 = Little or none of the outcome at this LOA is met by all of the masters graduates

Analysis of Survey Results – Current M/30 Curricula with BOK1 and BOK2

Nine of the ten participating institutions reported offering more than one masters program. Nine of the programs reported offering a master of science (MS) with thesis, five an MS without thesis but with a scholarly project, three a master of engineering (MEng) with a scholarly project, three an MEng with only coursework, and three with other options not included above. For the purposes of this paper, only the data collected for the MS with thesis program type is reported on here given the smaller number of responses for the other program types.

The M/30 survey results are graphically summarized in Tables 3A, 3B, 4A, and 4B. Tables 3A and 3B are for BOK1 Outcome 12 and Tables 4A and 4B are for BOK2 Outcomes 7, 8 and 15. Tables 3A and 4A show how many of the nine MS with thesis programs believe *all* of the outcome is fulfilled by *all* of their masters graduates for the applicable M/30 level of achievement in BOK1 and BOK2, respectively. Tables 3B and 4B show how many of the nine programs believe *most or all* of the outcome is fulfilled by *all* of their masters graduates for the applicable levels of achievement. An analysis of these tabulated results follows.

All of the surveyed programs believe that all of their master-level graduates are able to fully achieve Level 4 for BOK 1 Outcome 12 (Specialized Area of Civil Engineering; Table 3A). The expected level of performance is, however, at Level 6 – Evaluation, and six programs suggested that most or all of this outcome is achievable by all of their master-level graduates with all nine programs believing that most or all of this outcome was achievable by their masters graduates to Level 5 (Table 3B).

The BOK2 Outcome 15 (Technical Specialization) results are congruent with the corresponding results for BOK1 Outcome 12 (Specialized Area of Civil Engineering). All nine programs believed that most or all of this outcome is met by all of their graduates (Table 4B). The BOK2 differs, however, from the BOK1 in that it assigned Level 6 of this outcome to the experience (E) component of the fulfillment pathway; it is no longer an expectation of the M/30 component as it is for BOK1. Five of the nine programs report that all of their masters graduates achieve all of the targeted outcome at Level 5.

Outcome 7 (Experiments) of the BOK2 is targeted for the M/30 at Level 5. Lower levels are assigned to the undergraduate program. Seven of the nine MS with thesis programs believe that most or all of this outcome is achieved by all of their master-level graduates (Table 4B). Only

four programs believe that all of their masters graduates are able to achieve all aspects of this outcome (Table 3B).

Outcome 8 (Problem Recognition and Problem Solving) of the BOK2 is targeted at Level 4 for the M/30. Lower levels are assigned to the undergraduate program. All nine of the responding programs believe that their masters graduates achieve most or all of this outcome (Table 4B) with five reporting all of their graduates are able to achieve all of this outcome (Table 3B).

This simple analysis of the state of current Master-level curriculum to meet the expectations of the BOK1 and BOK2 at the M/30 stage has revealed that there are a variety of curricula approaches to master's education. Although other master-level approaches are common, the committee was able to report only on the MS with thesis given the small sample sizes for the other curricula approaches. Also, this data is very new and the committee has not had an opportunity to explore possible explanations for some of the above observations.

The Next Steps

While the 10 institutions surveyed represent a wide spectrum of institution types, the sampling obviously is very limited. A next step in the effort is to extend the survey to include a larger number of programs. This is important to both the B and M/30 components of the survey. With respect to the M/30 surveys, an expanded sampling of institutions will also allow analyses of other master's program types beyond the MS with thesis.

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		LEVEL OF ACHIEVEMENT					
OUTCOME #	OUTCOME TITLE	1	2	3	4	5	6
1	Math & Science	B	B	B			
2	Experiments	B	B	B	B	B	E
3	Design	B	B	B	B	B	E
4	Multidisciplinary Teams	B	B	B	E		
5	Engineering Problems	B	B	B	E	E	E
6	Professional & Ethics	B	B	B	B	E	E
7	Communication	B	B	B	B	E	
8	Impact of Engineering	B	B	B	E	E	
9	Lifelong Learning	B	B	B	E	E	
10	Contemporary Issues	B	B	B	E	E	
11	Engineering Tools	B	B	B	E		
12	Tech Specialization ^^	M/30	M/30	M/30	M/30	M/30	M/30
13	Proj Mgmt, Const., Asset	B	B	E	E	E	
14	Business & Public Policy	B	B	E	E		
15	Leadership	B	B	E			

^^BOK Outcome 12 is assigned entirely to post baccalaureate education.

Figure 1: Graphical Representation of the BOK1 Outcome Rubric

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

Figure 2: Graphical Representation of the BOK2 Outcome Rubric

Table 1A: Number of Programs (out of 10) Reporting *All* of the BOK1 Outcomes at Each LOA are Fulfilled by *All* of Their Baccalaureate Graduates

		LEVEL OF ACHIEVEMENT					
OUTCOME #	OUTCOME TITLE	1	2	3	4	5	6
1	Math & Science	9	9	8**	2	0	0
2	Experiments	10	10	10	9	2**	0
3	Design	10	10	10	8	4**	0
4	Multidisciplinary Teams	9	8	7**	0	0	1
5	Engineering Problems	10	9	9**	1	0	0
6	Professional & Ethics	9	8**	6	5	0	0
7	Communication	10	10	8	7**	1	0
8	Impact of Engineering	9	7**	4	1	0	0
9	Lifelong Learning	10	9	7**	1	0	0
10	Contemporary Issues	9	7**	5	1	0	0
11	Engineering Tools	9	9	9**	3	0	0
12	Tech Specialization ^^	8	6	6	0	0	0
13	Proj Mgmt, Const., Asset	8	8**	3	0	0	0
14	Business & Public Policy	7	5**	1	0	0	0
15	Leadership	9	7**	3	0	0	0

^^ BOK Outcome 12 is assigned entirely to post baccalaureate education.

** Level of achievement (LOA) that the authors believe is dictated by the General Criteria for Baccalaureate Level Programs and the related Civil Engineering Program Criteria.

Table 1B: Number of Programs (out of 10) Reporting *Most or All* of the BOK1 Outcomes at Each LOA are Fulfilled by *All* of Their Baccalaureate Graduates

		LEVEL OF ACHIEVEMENT					
OUTCOME #	OUTCOME TITLE	1	2	3	4	5	6
1	Math & Science	10	10	10**	3	0	0
2	Experiments	10	10	10	10	4**	0
3	Design	10	10	10	10	10**	1
4	Multidisciplinary Teams	10	10	10**	4	1	1
5	Engineering Problems	10	10	10**	4	1	1
6	Professional & Ethics	10	10**	9	7	0	0
7	Communication	10	10	10	10**	2	1
8	Impact of Engineering	10	9**	6	2	1	0
9	Lifelong Learning	10	10	10**	4	0	0
10	Contemporary Issues	10	9**	8	3	1	0
11	Engineering Tools	10	10	10**	5	0	0
12	Tech Specialization ^^	8	7	6	4	2	1
13	Proj Mgmt, Const., Asset	10	10**	6	1	0	0
14	Business & Public Policy	9	8**	2	0	0	0
15	Leadership	10	9**	6	1	0	0

^^ BOK Outcome 12 is assigned entirely to post baccalaureate education.

** Level of achievement (LOA) that the authors believe is dictated by the General Criteria for Baccalaureate Level Programs and the related Civil Engineering Program Criteria.

Table 2A: Number of Programs (out of 10) Reporting *All* of the BOK2 Outcomes at Each LOA are Fulfilled by *All* of Their Baccalaureate Graduates

		LEVEL OF ACHIEVEMENT					
OUTCOME #	OUTCOME TITLE	1	2	3	4	5	6
1	Mathematics	10	10	9	2	0	0
2	Natural Sciences	10	10	9	2	0	0
3	Humanities	6	5	3	2	0	0
4	Social Sciences	7	4	2	1	0	0
5	Material Science	9	7	5	2	0	0
6	Mechanics	10	9	9	7	0	0
7	Experiments	9	9	9	8	2	0
8	Prob Recog/Solving	10	9	9	2	1	0
9	Design	9	10	9	8	7	0
10	Sustainability	6	3	2	2	0	0
11	Contemp Issues/History	7	3	2	1	0	0
12	Risk & Uncertainty	7	3	2	1	0	0
13	Proj Management	9	9	6	0	0	0
14	Breadth in CE	10	10	9	9	0	0
15	Tech Specialization	9	7	5	3	0	0
16	Communication	10	10	8	8	2	0
17	Public Policy	5	4	0	0	0	0
18	Business & Public Admin	7	4	0	0	0	0
19	Globalization	5	3	1	0	0	0
20	Leadership	9	7	4	0	0	0
21	Teamwork	9	8	7	2	0	1
22	Attitudes	7	7	0	0	0	0
23	Lifelong Learning	10	10	9	0	0	0
24	Professional & Ethics	10	10	7	5	0	0

Table 2B: Number of Programs (out of 10) Reporting *Most of All* of the BOK2 Outcomes at Each LOA are Fulfilled by *All* of Their Baccalaureate Graduates

		LEVEL OF ACHIEVEMENT					
OUTCOME #	OUTCOME TITLE	1	2	3	4	5	6
1	Mathematics	10	10	10	3	0	0
2	Natural Sciences	10	10	10	4	0	0
3	Humanities	10	7	5	4	0	0
4	Social Sciences	10	7	5	2	0	0
5	Material Science	9	8	6	3	0	0
6	Mechanics	10	10	10	9	0	0
7	Experiments	10	10	10	9	4	0
8	Prob Recog/Solving	10	10	10	4	2	1
9	Design	9	10	10	10	9	1
10	Sustainability	7	4	3	2	0	0
11	Contemp Issues/History	9	7	6	1	1	0
12	Risk & Uncertainty	8	5	5	1	0	0
13	Proj Management	9	9	8	2	1	0
14	Breadth in CE	10	10	10	9	0	0
15	Tech Specialization	9	7	6	4	1	0
16	Communication	10	10	10	10	3	1
17	Public Policy	8	4	1	0	0	0
18	Business & Public Admin	8	6	1	0	0	0
19	Globalization	6	6	4	1	0	0
20	Leadership	9	9	5	0	0	0
21	Teamwork	10	10	10	5	0	1
22	Attitudes	7	7	4	0	0	0
23	Lifelong Learning	10	10	10	3	0	0
24	Professional & Ethics	10	10	10	9	0	0

Table 3A: Number of Programs (out of 9) Reporting *All* of the BOK1 Outcome at Each LOA is Fulfilled by *All* of Their MS with Thesis Graduates

		LEVEL OF ACHIEVEMENT					
OUTCOME #	OUTCOME TITLE	1	2	3	4	5	6
12	Technical Specialization	9	9	9	9	2	0

Table 3B: Number of Programs (out of 9) Reporting *Most or All* of the BOK1 Outcome at Each LOA is Fulfilled by *All* of Their MS with Thesis Graduates

		LEVEL OF ACHIEVEMENT					
OUTCOME #	OUTCOME TITLE	1	2	3	4	5	6
12	Technical Specialization	9	9	9	9	9	6

Table 4A: Number of Programs (out of 9) Reporting *All* of the BOK2 Outcomes at Each LOA are Fulfilled by *All* of Their MS with Thesis Graduates

		LEVEL OF ACHIEVEMENT					
OUTCOME #	OUTCOME TITLE	1	2	3	4	5	6
7	Experiments					4	
8	Prob Recog/Solving				6		
15	Tech Specialization		9	9	9	5	

Table 4B: Number of Programs (out of 9) Reporting *Most or All* of the BOK2 Outcomes at Each LOA are Fulfilled by *All* of Their MS with Thesis Graduates

		LEVEL OF ACHIEVEMENT					
OUTCOME #	OUTCOME TITLE	1	2	3	4	5	6
7	Experiments					7	
8	Prob Recog/Solving				9		
15	Tech Specialization		9	9	9	9	