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Abstract

In response to major societal changes resulting from world urbanization and population increase, manmade and natural disasters, and globalization of manufacturing and design, the American Society of Civil Engineers (ASCE) has launched a profound reform of engineering education which aims at evolving civil engineering in the 21st century. ASCE has recently released a Body of Knowledge (BOK version 2, 2007) in response to the changing needs of educating engineers to meet societal challenges. This paper examines how BOK2 applies the concept of learning taxonomy, originally developed by Bloom (1956) and later revised by Anderson and Krathwohl (2001). This learning taxonomy articulates learning in a two dimensional framework that includes knowledge dimensions and cognitive process dimensions. The knowledge dimensions include factual, conceptual, procedural, and metacognitive knowledge. The cognitive process dimensions include six levels characterized by descriptors and actions including: remember, understand, apply, analyze, create, and evaluate. BOK2, which was developed using Bloom's taxonomy, is examined using Anderson's and Krathwohl's revised learning taxonomy as a guide. This is found to be an important step toward reforming engineering education. Indeed ASCE is among the first engineering profession to have adopted such a progressive approach to reforming engineering education. Our analysis suggests that BOK2 can become more effective pedagogically using the revised taxonomy, allowing it to aggressively promote the creativity required for the engineering profession to tackle the enormous challenges of the 21rst century.

Introduction and Overview

We live in an era with unprecedented changes due to dramatic advances in technology on many fronts. The explosive growth in computing and communication has revolutionized the way we work and live. Increasingly, the engineering work force requires that teams work with global foci. This is particularly the case for the field of civil engineering with dilemmas associated with population changes, natural disasters, and global forces. These forces of globalization, demographics, and technological advances are changing the role of engineering in society (Duderstadt, 2008), calling for changes in the way universities address the engineering profession and education. The American Society of Civil Engineers (ASCE) has developed a Body of Knowledge (BOK version 2) in an effort to respond to the changing needs of educating engineers to meet societal challenges. This paper responds to the ASCE's BOK2 and is guided by the following conceptual question: *How we can the recently released ASCE Body of Knowledge 2 (BOK2) be effectively utilized to improve engineering education?* Our primary objective for this paper is to review and analyze ASCE BOK2 from the points of view of educational psychology and engineering education and to suggest interpretations ad revisions to the BOK2 to facilitate its implementation in engineering schools. Accordingly, we utilize the frame of Anderson and Krathwohl's (2001) learning taxonomy to guide us in these efforts.

Review of Engineering Education

There have been many national level studies about critical issues facing the nation and related the crises in engineering education (NAE, 2004, 2005). With outsourcing of engineering jobs, there is a growing concern about the level of interest among young students choosing engineering field. While the number of engineering graduates per year has remained steady at approximately 70,000 in the United States, in the past decade the number of engineering graduates per year from China and India has grown at a significant rate. With the world becoming "flat" due to globalization, increasingly, jobs requiring basic technical skills are moving beyond U.S. borders by companies in efforts to reduce costs. Engineering graduates from the United States must bring added value and higher-level skills including innovation, a problem solving approach, and leadership to garner higher salary jobs in U.S. companies. The call from various technical reports on engineering education demands that U.S. higher education institutions produce this kind of engineers. Accordingly, there is an urgent need for reforming and enhancing engineering education to address these needs. This reform effort is best served through a merging of engineering education with best practices in educational psychology.

Traditional curriculum in engineering education involves deductive instruction in which the instructors lecture on general principles with limited application of the principles to real life engineering situations and simulations. Deductive instructional approaches have significant limits in preparing engineers for a changing global society as required by NAE (2005). The serious nature of the necessity for engineering education reform requires radically new and innovative curricular, pedagogical and assessment approaches. Such approaches must focus on inductive teaching and situated learning. Inductive teaching refers to pedagogical approaches that include active engagement by students in collaborative problem solving rather than disengaging lecturing, which is the traditional pedagogical approach of engineering education. Situated learning involves student engagement in real life problem solving as opposed to disconnected based lectures. Moreover, inductive approaches with situated learning opportunities include: inquiry learning, problem-based learning, vignette instruction and case-based instruction (Prince & Felder, 2006). We posit that these innovative approaches be adopted to meet the needs of engineers in our changing world. Learning taxonomies can serves as medium to guide such pedagogical and curricular changes. Benjamin Bloom (1956) and Loren Anderson and Richard Krathwohl (2001) have formulated two widely recognized learning taxonomies. Anderson and Krathwohl's taxonomy is a revision of Bloom's taxonomy. Bloom's taxonomy provides historical context for learning taxonomies.

Bloom's Taxonomy

In 1956, Benjamin Bloom headed a group of educational psychologists who developed a classification of levels of intellectual behavior important in learning in the form of a learning taxonomy. Bloom's work revealed that in excess of ninety-five percent of the assessment related tasks that students encounter and elementary, secondary and college levels require them to think and perform only at lowest possible level...the recall of information. Accordingly, Bloom identified six levels within what he determined was a cognitive domain, which pyramided from simple recall or recognition of facts, as the lowest level, through increasingly more complex and abstract mental levels, to the highest order which he classified as evaluation. Verb usage that represent intellectual activity on each level include the following per Bloom's taxonomy: (1) *Knowledge:* Instruction using the following are applicable to this level-arrange, define, duplicate, label, list, memorize, name, order, recognize, relate, recall, repeat, or reproduce state. (2) *Comprehension:* Instruction using the following are applicable to this level-classify, describe, discuss, explain, express, identify, indicate, locate, recognize, report, restate, review, select, or translate. (3) *Application:* Instruction using the following are applicable to this level-apply, choose, demonstrate, dramatize, employ, illustrate, interpret, operate, practice, schedule, sketch, solve, use, or write. (4) *Analysis*: Instruction using the following are applicable to this level-analyze, appraise, calculate, categorize, compare, contrast, criticize, differentiate, discriminate, distinguish, examine, experiment, question, or test. (5) *Synthesis:* Instruction using the following are applicable to this level-arrange, assemble, collect, compose, construct, create, design, develop, formulate, manage, organize, plan, prepare, propose, set up, and write. (6) *Evaluation:* Instruction using the following are applicable to this level-appraise, argue, assess, attach, choose compare, defend estimate, judge, predict, rate, core, select, support, value, or evaluate.

However innovative and exemplary Bloom's work was for its era (1956), the material now used in support of his work has become outdated and does not fully exemplify the pedagogical and curricular expectations required for education engineers with global foci per NAE. It has been found to be lacking in multidimensionality particularly at college and university levels in terms of meeting the increasing challenges facing higher education faculty. This is particularly true in the case of research universities with engineering schools where engineering education research is of focus. Professional organizations associated with the field of Civil Engineering including ASCE have clear expectations for preparing engineers who are globally focused leaders who and reflect a skills set that requires multidisciplinarity, research, and leadership that can be inspired with, facilitated by and developed via engineering curriculum and assessment that is aligned to strong and contemporary learning taxonomies.

Comparisons Between Old and Revised Learning Taxonomies

Although Bloom's Taxonomy (1956) has proven to be useful to educators, university faculty, and students historically, recent decades have given rise to numerous criticisms of Bloom's work, implying that the model is out dated and somewhat unidimesional. These criticisms include concerns with setting applicability, contemporary language, and process conceptualization.

In 2001, Anderson and Krathwohl adapted Bloom's taxonomy model to fit the needs of today's classroom in K-12 and university settings by employing outcome-oriented language, workable, contemporary objectives, and active pedagogically focused verbs implying necessary interaction, engagement and situation-based activity in learning. Accordingly, the highest level of development in terms of the cognitive dimension is to create rather than to evaluate. Create recognizes the importance of creativity in innovative engineering practices. An additional critical component that differentiates Anderson and Krathwohl's taxonomy from Bloom's (1956) is that it lays out components so they can be considered and used inductively, situationally and multi-dimensionally. While the levels of knowledge were indicated in Bloom's original work including factual, conceptual, and procedural -- these were never fully utilized by educators at all levels (K-12 through university) because most of what educators were provided in training consisted of a simple chart with the listing of levels and related accompanying verb usage. The full breadth of the levels and types of knowledge were rarely discussed in any instructive way. The updated Anderson and Krathwohl learning taxonomy (2001) added metacognitive processes to the array of knowledge dimensions. Metacognitive processes provide the intersections between dimensions and domains as the processes that impact the levels of knowledge. Structural changes in the revised learning taxonomy are logically devised as well. Bloom's original cognitive taxonomy was uni-dimensional. The revised taxonomy takes the form of a multidimensional perspective on learning and cognition. One dimension, the knowledge dimension, identifies the kind of knowledge to be learned. A second dimension, the cognitive process dimension, identifies the process used to learn. The intersection of the knowledge and cognitive process dimensions form twenty-four separate dimensions of cognition and learning from which instruction can be guided, curriculum can be formed and assessment can be conducted.

The Knowledge Dimension in Anderson and Krathwohl's learning taxonomy is inclusive of four levels that are defined as Factual, Conceptual, Procedural, and Meta-Cognitive. The Cognitive Process Dimension consists of six levels that are defined as *Remember, Understand, Apply, Analyze, Evaluate,* and *Create (*Overbaugh, & Schultz, 2004). Each of the four knowledge dimensions is subdivided into either three or four categories. The cognitive process dimension levels are also subdivided with the number of sectors in each level ranging from a low of three to a high of eight categories. The resulting multidimensionality, containing 19 subcategories is most helpful to educators in writing instructional objectives, aligning curriculum, and conducting assessment. Figure 1 represent a comparison between Bloom's Taxonomy and Anderson and Krathwohl's Taxonomy hierarchically.

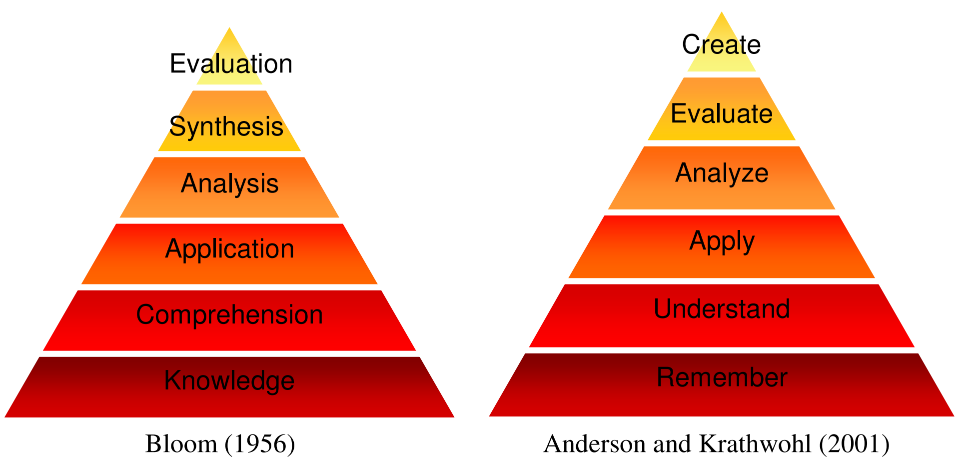

Figure 1: Comparison of Old with New Taxonomies of Learning

It should be noted that the verbage has changed in the hierarchy of the taxonomies and adaptations have been made to reflect what current curricular and pedagogical practice experts (Pintrich, 2003) as best practices. As previously described, Anderson and Krathwohl's taxonomy builds upon the work of Bloom as they propose a multidimensional taxonomy from which rubrics for assessment can be developed and curriculum can be created (Table 1).

Table 1. Anderson and Krathwohl's (2001) Taxonomy of Learning

	Cognitive Dimension					
Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual						
Conceptual						
Procedural						
Metacognitive						

Table 1 allows for engineering educators to design and deliver curriculum that is pedagogically sound and represents inductive, creative, and innovative practices. Through the use of the taxonomy table, faculty can be certain that they address all six cognitive processes while simultaneously addressing the four components in the knowledge dimension. The knowledge dimension includes four types of knowledge: factual, conceptual, procedural and metacognitive. *Factual knowledge* includes the basic elements that students need to know to be acquainted with a discipline and solve problems in it. Specifically, *factual knowledge* per Anderson and Krathwohl includes knowledge of terminology, specific details, and elements. *Conceptual knowledge* refers to the interrelationship among the basic elements within a larger structure that enable them to function together. Specifically this category relates to knowledge of classifications, generalizations, categories, theories, models and structures. *Procedural knowledge* refers to how to do something, methods of inquiry, and criteria for using skills, algorithms, techniques and methods. Specifically, *procedural knowledge* relates to knowledge of subject-specific skills, algorithms, techniques, methods and criteria for determining when to use appropriate procedures. *Metacognitive knowledge* refers to knowledge of cognition in general in addition to knowledge of one's own cognitive processes. Specifically, metacognition is strategic knowledge, knowledge about cognitive tasks and knowledge about self and one's learning. Combining these four knowledge dimensions with the six cognitive processes in the taxonomy are the key to the multi-dimensionality of learning per Anderson and Krathwohl. This multidimensional focus enables educators to engage in inductive, situative instructional practices.

Learning Taxonomies as a Means of Assessing Students Knowledge

Not only can engineering educators use the taxonomy for curriculum development, it can and should be used for assessing engineering students' learning across cognitive process domains. To engage in assessment using Anderson and Krathwohl's taxonomy, rubrics have become a useful practice. A rubric is defined as a scoring tool that lists the criteria for judging or grading a piece of work. Generally, a rubric lists the information and elements the student must have included in a work product to receive a certain score, grade or rating. It is a set of criteria and standards linked to learning objectives that is used to assess a student's performance on papers, projects, essays, and other assignments. Rubrics allow for standardized evaluation according to specified criteria, making grading simpler, uniform and transparent. Rubrics represent attempts to delineate consistent assessment criteria. They allow teachers and students to assess criteria, which are complex and provide grounds for self-evaluation, reflection and peer review. They are aimed at accurate and fair assessment, fostering understanding and indicating the way to proceed with subsequent learning/teaching. Essentially, rubrics specify the level of performance expected for several levels of quality. These levels of quality may be written as different ratings (as in excellent, good, needs improvement) or as numerical scores (as in 4, 3, 2, 1), which are then totaled to form a total score which then is associated with a grade. Rubrics can help students and faculty define "quality." Rubrics can also help students judge and revise their work before handing in their assignments. Rubrics are critical components for measuring knowledge and judging instructional products. Anderson and Krathwohl's taxonomy can be used to guide the engineering educator in delineating clear criteria for judging course assignments with a degree of standardization. Anderson and Krathwohl's learning taxonomy can be used as a means of actualizing ASCE's Body of Knowledge 2.

Review of ASCE Body of Knowledge version 2 (BOK2)

It is widely recognized that civil engineering is a demanding field that requires a broad knowledge base and combinations of skills to successfully practice as a professional. The purpose of BOK2 is to present the recommendations of the ASCE Body of Knowledge Committee regarding the knowledge, skills, and attitudes required to enter into professional practice in civil engineering, how the body of knowledge can be fulfilled by tomorrow's aspiring engineers, and identification of who should guide the learning of the engineering student and engineer intern. BOK2 was developed in response to broad stakeholder feedback about the ASCE's first Body of Knowledge (BOK1) and ASCE's Vision for Civil Engineering in 2025. The ASCE (2007) vision for the future of Civil Engineering can be found in the report entitled "The Vision for Civil Engineering in 2025." ASCE is energetically engaged in efforts to create better alignment between academic experience and anticipated future workplace requirements. ASCE collaborates with other professional organizations to offer "Excellence in Engineering Education" teaching workshop for engineering faculty. ASCE (2008) supports the attainment of a "Body of Knowledge-2" for entry into the practice of civil engineering at the professional level. The ASCE Body of Knowledge-2 recommends the adoption of the following engineering education and experience requirements as a prerequisite for licensure: (1) A baccalaureate degree (B); (2) A master's degree, or approximately 30 coordinated graduate or upper level undergraduate credits or the equivalent agency/organization/professional society courses providing equal quality and rigor (M/30); and (3) Appropriate experience based upon broad technical and professional practice guidelines that provide sufficient flexibility for a wide range of roles in engineering practice (E).

Currently, the BOK2 utilizes Bloom's taxonomy for design of civil engineering curriculum and assessment of student learning. For reasons described in our comparison between Bloom's and Anderson and Krathwohl's taxonomy, we favor use of Anderson and Krathwohl's taxonomy over Bloom's. Accordingly, this updated taxonomy can serve as structural guide for development of curriculum and assessment that will assist ASCE in meeting its goals set forth for BOK-2.

The complete BOK2, which can be found in American Society of Civil Engineers (2008), is not duplicated in this paper due to limitation on the number of pages. Table 2 provides only excerpts of the first two BOK2 outcomes, namely Mathematics, and Natural Sciences. BOK2 contains a total 24 rows for the knowledge dimension and 6 columns for the level of cognitive achievement. Each cell contain rubric that students must satisfy in order to reach a certain knowledge level in a knowledge topic. Each rubric has a verb (outlined in bold letter) for describing the cognitive level, followed by object(s) for describing the knowledge dimension. For instance, "**Define** key factual information related to mathematics through differential equations." has for verb "define," which means that students must remember "key factual information related to mathematics through differential equations," e.g., for instance to recognize a particular type of ordinary differential equation.

Outcome title	*Level of cognitive achievement*					
	1 Knowledge	*2 Comprehension*	*3 Application*	*4 Analysis*	*5 Synthesis*	*6 Evaluation*
	To enter the practice of civil engineering at the professional level, an individual must be able to demonstrate this level of achievement					
1 Mathematics	***Define*** key factual information related to mathematics through differential equations. (B)	***Explain*** key concepts and problem-solving processes in mathematics through differential equations. (B)	***Solve*** problems in mathematics through differential equations and ***apply*** this knowledge to the solution of engineering problems. (B)	***Analyze*** a complex problem to determine the relevant mathematical principles and then apply that knowledge to solve the problem.	***Create*** new knowledge in mathematics.	***Evaluate*** the validity of newly created knowledge in mathematics.
2 Natural sciences	***Define*** key factual information related to calculus-based physics, chemistry, and one additional area of natural science. (B)	***Explain*** key concepts and problem-solving processes in calculus-based physics, chemistry, and one additional area of natural science. (B)	***Solve*** problems in calculus-based physics, chemistry, and one additional area of natural science and ***apply*** this knowledge to the solution of engineering problems. (B)	***Analyze*** complex problems to determine the relevant physics, chemistry, and/or other areas of natural science principles and then apply that knowledge to solve the problem.	***Create*** new knowledge in physics, chemistry, and/or others areas of natural science.	***Evaluate*** the validity of newly created knowledge in physics, chemistry, and/or others areas of natural science.

Table 2. Excerpt of BOK2 (American Society of Engineers, 2008)

As shown in Figure 2 (below), BOK2 has a total of 24 rows by 6 columns, which results in 144 cells. Each row corresponds to a knowledge subject, and each column to a cognitive level. BOK2 does not require education programs to complete all 144 cells. An education program should include cells as relevant to its educational objectives. BOK requires 73 cells for the baccalaureate; 6 for a Master's degree or 30-unit equivalent courses; and 17 for professional experience. Hereafter Figure 2 will be referred to for analyzing BOK2 in relation to program objectives, i.e., B, B+M/30 or B+M/30+E. It is also instructive to analyze the complete BOK2 to understand what educational aspects may be included in addition to those referred to as B, B+M/30, and B+M/30+E.

	1 Knowledge	2 Comprehension	3 Application	4 Analysis	5 Synthesis	6 Evaluation
1 Mathematics	B	B	B			
2 Natural sciences	B	B	B			
3 Humanities	B	B	B			
4 Social sciences	B	B	B			
5 Materials science	B	B	B			
6 Mechanics	B	B	B	B		
7 Experiments	B	B	B	B	M/30	
8 Problem recognition and solving	B	B	B	M/30		
9 Design	B	B	B	B	B	E
10 Sustainability	B	B	B	E		
11 Contemporary issues and historical perspectives	B	B	B	E		
12 Risk and uncertainty	B	B	B	E		
13 Project management	B	B	B	E		
14 Breadth in civil engineering areas	B	B	B			
15 Technical specialization	B	M/30	M/30	M/30	M/30	E
16 Communication	B	B	B	B	E	
17 Public policy	B	B	E			
18 Business and public administration	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 and ethical responsibility	B	B	B	B	E	E

Figure 2. BOK2 Levels of Achievement for Bachelor of Sciences (B); Master or 30 Unit Equivalents (M/30) and Professional Experience (E).

Analysis of the BOK2

Anderson and Krathwohl (2001) have presented a comprehensive mechanism for analyzing a set of educational objectives. Our goal is to apply their approach to analyze BOK2. Anderson and Krathwohl (2001) first recognize that there are four important different questions related to (1) learning, (2) instruction, (3) assessment, and (4) alignment. In this context, our goal is to address the learning question, which is to define what is important for students to learn in the limited school and classroom time available. The questions how to plan and deliver instruction, how to select and design assessments tools and methods, and how to align objectives, instruction, and assessment are all valuable questions, but are beyond the scope of this paper. In the context of specificity of objectives defined by Anderson and Krathwohl (2001), BOK2 falls into the category of global objectives. The time required to achieve BOK2 measures in terms of years, provide a vision, and fall into a multi-year curriculum. They are neither educational nor instructional. Educational objectives usually require weeks to months, while instructional objectives correspond to hours or days, and apply to lessons and daily educational or practice activities.

It is worth noticing that the taxonomy approach can be applied to not only the BOK2 global objectives, but also educational and instructional objectives. It can also be applied not only to learning, but to instruction, assessment and alignment. Hereafter we are focused on learning with global objectives. The contents of BOK2 tables were analyzed using the text functions of EXCEL. The original PDF materials were downloaded from the ASCE website at http://www.asce.org/professional/educ/ and converted into a categorized spreadsheet for analyses. The spreadsheet was then analyzed using Anderson and Krathwohl's Taxonomy (2001). The analysis was two-dimensional; it is applied to the verbs, which characterizes the cognitive level as well as the knowledge dimension.

Figure 3 (below) illustrates the frequency distribution of verbs used in the complete BOK2, BOK2-B and BOK2-B+M/30+E. BOK2 uses 37 different verbs. These verbs have been sorted according to their frequency in the complete BOK2. The most commonly used verb is "Evaluate" in BOK2, while it becomes "Explain" in both BOK-B and BOK2-B+M/30+E. This implies that the education objectives of BOK-B and BOK2-B+M/30+E prefer a lower cognitive level "Explain," to a much higher level of cognitive achievement "Evaluate."

Tables 3-5 summarize the verb counts after aggregating verbs according to knowledge category and cognitive levels for the complete BOK2, BOK2-B, and BOK2-B+M/30+E.

As illustrated in Tables 3-5, the total numbers of verbs is 182 for the complete BOK2, 92 for the BOK2-B, and 125 for BOK2-B+M/30+E. As shown in Table 3, BOK2-B+M/30+E has 26 verbs about remembering facts, 18 verbs about understanding concepts, 32 verbs about applying procedure, and 11 about analyzing procedures. The less used verbs are about understanding facts (7) and analyzing concepts (6). In contrast to the complete BOK2, there are much fewer verbs in the metacognitive category and the cognitive levels "Evaluate" and "Create." Similar observations about the lack of metacognitive knowledge and creation/evaluation can be made about BOK2-B.

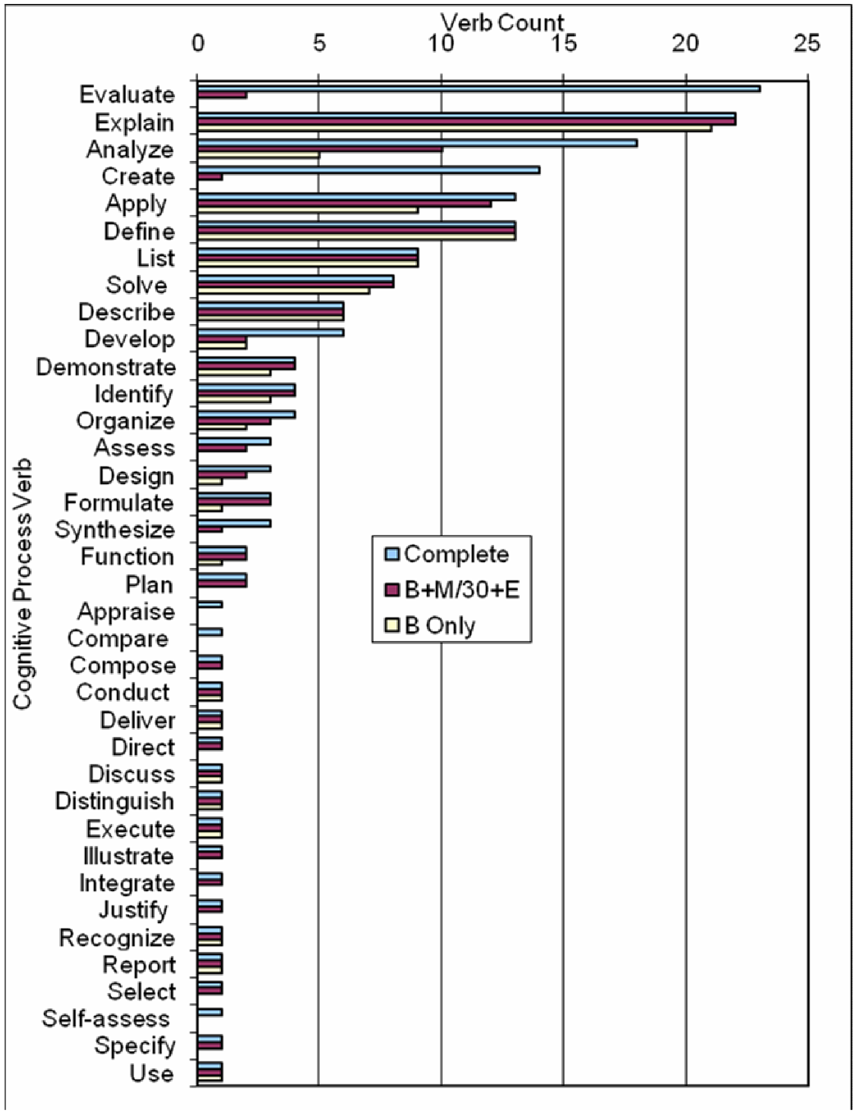

Figure 3. Freqency distrubtion of cognitive process dimensions in the complete BOK2, the 4-year Baccalaureate program (B), and new combined B+M/30 program.

Table 3. Total number of verbs used in complete BOK2 and aggregated in the knowledge and cognitive level dimensions of Anderson and Krathwohl (2001).

Knowledge Category	Remember	Understand	Apply	Analyze	Evaluate	Create	Grand Total
Factual	26	7		1			34
Conceptual	1	18	3	8	2	17	49
Procedural	1	5	35	17		12	70
Metacognitive			1	1	24	3	29
Grand Total	28	30	39	27	26	32	182

Table 4. Total number of verbs used in BOK2-B and aggregated in the knowledge and cognitive level dimensions of Anderson and Krathwohl (2001).

Knowledge Category	Remember	Understand	Apply	Analyze	Evaluate	Create	Grand Total
Factual	26	7					33
Conceptual	1	16	2	1	1		21
Procedural	1	5	24	6			36
Metacognitive			1			1	2
Grand Total	28	28	27	7	1	1	92

Table 5. Total number of verbs used in BOK2-B+M/30+E and aggregated in the knowledge and cognitive level dimensions of Anderson and Krathwohl (2001).

Knowledge Category	Remember	Understand	Apply	Analyze	Evaluate	Create	Total
Factual	26	7		1			34
Conceptual	1	18	3	6	1	4	33
Procedural	1	5	32	11		3	52
Metacognitive			1		3	2	6
Grand Total	28	30	36	18	4	9	125

Based on the analysis of verbs, one may be tempted to draw the conclusions that engineering is all about applying procedures, understanding concepts, and remembering facts. This may not be the right message to send to K-12 students or university students to attract them in engineering. This undermines creativity which has been encouraged as a means to attract and retain students in engineering and ultimately to inspire innovative engineering practices.

The analysis above may assist engineering educators in devising new programs in civil engineering which are more creative and responds to the plea of NAE for developing the next generation of engineers with foci on innovation and addressing Grand Challenges. Educators should not feel restrained by BOK2 when they develop and revise programs. One of the greatest achievements of BOK2 is to exploit the knowledge of learning taxonomy. BOK2 has started a momentum that will lead forward the reform in engineering education, not only in civil engineering, but in many other fields of engineering.

Subsequent studies will provide examples of rubrics illustrating how to develop a curriculum in the higher cognitive category, i.e., analyze, create, and evaluate. It is our belief that BOK2 has exercised caution in using the learning taxonomy as it was concerned to raise the bar too high and face rejection from its constituencies. This is a wise strategy in implementing reform in an engineering field, which has been in existence for centuries. However, we believe that leading research and educational institutions should not feel constrained by the limitations of BOK2, and should build upon the bases that BOK2 has provided for educators in civil engineering. Any engineering education reform of such a magnitude is likely to go through bumpy roads while emerging.

Conclusions

We commend the American Society of Civil Engineers (ASCE) in moving forward and merging best practices in engineering education with ABET criteria (Shuman, Besterfield-Sacre, & McGourty, 2005) and with educational psychology curricular, learning, assessment and pedagogical principles. This effort demonstrates much promise for the field in terms of engineering education, research and exemplary practices. We wish to contribute to this effort through refocusing ASCE's efforts with the use of a contemporary taxonomy of learning and practices aligned to this comprehensive, multidimensional taxonomy.

Our paper examines how BOK2 applies the concept of a learning taxonomy, which was originally developed by Bloom (1956) and later revised by Anderson and Krathwohl (2001). This learning taxonomy maps learning in a multi-dimensional framework that includes knowledge dimension and cognitive process dimension. The knowledge dimension is further subdivided in factual, conceptual, procedural, and metacognitive knowledge. The cognitive process dimension is divided into six levels characterized by verbs, namely remember, understand, apply, analyze, create, and evaluate. BOK2, which was developed using the original Bloom's taxonomy, is examined within the revised taxonomy of Anderson and Krathwohl, and is found to be a great step forward to reform engineering education. Indeed ASCE is among the first engineering professions to have adopted such a progressive approach to reforming engineering education. Our analysis suggests that BOK2 can become more effective using the newer taxonomy, and should not constraint its educational objectives, but be more aggressive in promoting the creativity required for the engineering profession to tackle the enormous and innovative challenges of the 21rst century.

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