The Practitioners' Point of View of the ASCE Body of Knowledge

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The Practitioners' Point of View of the ASCE Body of Knowledge

Introduction

The American Society of Civil Engineers has established the Body of Knowledge 3 Task Committee (BOK3TC) to revisit the 2^{nd} edition of the Body of Knowledge (BOK2) report. The Body of Knowledge defines the knowledge, skills and attitudes needed to enter into the professional practice of civil engineering. The BOK2 Task Committee identified 24 outcomes at certain desired levels of achievement that civil engineers need to possess at the time of licensure. All 24 outcomes are described in accordance with Blooms taxonomy for the cognitive domain. The cognitive domain is one of three domains and refers to the educational objectives that deal with the recall recognition of knowledge and the development of intellectual abilities and skills.

The BOK3TC initiated work in October 2016 and will publish a draft report for public comment in 2018. The final document will be published in early 2019. The study includes three op-in online surveys. The first was conducted in March 2017, the second in November 2017 and a third in April 2018. The surveys sought input from constituents as to the relevancy of the outcomes, the appropriateness of defined levels of achievements, the validity of the definitions and to gauge perceived needs across civil engineers in academia, government, consulting, construction, sales, and so on.

In an afterthought, some members of the committee speculated whether there was a difference in perceptions between practitioners and academics. The survey was not designed to address this question, but the objective of this paper is to determine if there are any apparent differences in perceived needs based on the first two surveys. The paper focuses on the outcomes that practitioners identified as most important to an aspiring civil engineer in comparison to those identified by academia.

The structure of the BOK2 and BOK3 outcomes

The BOK2 outcomes are divided into three groups:

(A) Foundational outcomes achieved through the degree program: mathematics, natural sciences, humanities, and social sciences.

(B) Technical outcomes achieved through the degree program, continuing education, experience, and mentoring: material sciences, mechanics, experiments, problem recognition and solving, design, sustainability, contemporary issues and historical perspective, risk and uncertainty, project management, breadth in civil engineering, and technical specialization.

(C) Professional outcomes achieved through the degree program, experience and mentoring: communications, public policy, business and public administration, globalization, leadership, teamwork, attitudes, and professional and ethical responsibility.

Detailed commentaries on these outcomes, along with their rubrics in the cognitive domain and the desired level of achievement can be found in the report published by the BOK2 Task

Committee [1]

The BOK3TC initiated work in October 2016 and its progress through June 2017 was presented in an earlier paper by Fridley, et al [2]. It resulted in a revised list of cognitive domain outcomes to include the identification of ten new outcomes for a total of 36 proposed outcomes, a survey to obtain input from ASCE's constituency, and the analysis of the survey results.

Constituent input from first survey

The first survey sought input from constituents as to the relevancy of these outcomes, the appropriateness of defined levels of achievements, the validity of the definitions and to gauge perceived needs across civil engineers in academia, government, consulting, construction, sales, and so on. There were 303 responses with 29% representing academia, and 71% representing the rest of professionals including practitioners in consulting firms, in governments, construction firms, non-profit organizations, and retired from non-academia organizations. Fridley, et al [2] summarized the results in a handout which was distributed to the audience during the presentation of the paper in the 2017 ASEE conference.

Professor Angela Bielefeldt, a BOK3TC member, sorted the survey responses representing the academia professionals, and determined the ranking of outcomes as shown in Table 1. Similarly, the authors extracted the survey responses representing the non-academic professionals consisting of practitioners working in the engineering consulting firms, government, construction industries and non-profit organizations, and determined the ranking of outcomes. Then rankings by both practitioners and academia are shown side by side in Table 1 for comparison. There are 34 outcomes divided into quintiles, each quintile has seven outcomes except for the fifth quintile that includes the bottom six outcomes. The Rank/Quintile column is common to both rankings.

Table 1. First Survey Rankings of Outcomes by Practitioners and Academia

Practitioners' Response		Rank/ Quin-tile	Academia's Response	
Outcome	**Mean Response**		**Outcome**	**Mean Response**
Communication	4.76	1-Q1	Problem Recognition & Solving	4.78
Problem Recognition & Solving	4.74	2-Q1	Design	4.75
Design	4.73	3-Q1	Communication	4.74
Professional and Ethical Responsibility	4.71	4-Q1	Professional and Ethical Responsibility	4.67
Teamwork	4.68	5-Q1	Mechanics	4.64
Critical and Analytical Thinking	4.60	6-Q1	**Mathematics**	4.51
Risk and Uncertainty	4.56	7-Q1	Teamwork	4.47
Mechanics	4.52	8-Q2	Critical and Analytical Thinking	4.40
Lifelong Learning	4.46	9-Q2	Lifelong Learning	4.37
Material Science	4.44	10-Q2	Risk and Uncertainty	4.35
Project Management	4.31	11-Q2	Natural Sciences	4.27
Interpersonal Skills	4.29	12-Q2	Sustainability	4.21
Breadth in Civil Engineering Areas	4.23	13-Q2	**Experiments**	4.17

Safety	4.21	14-Q2	Leadership	4.03
Attitudes	4.19	15-Q3	Material Science	4.02
Sustainability	4.15	16-Q3	Breadth in Civil Engineering Areas	4.01
Leadership	4.15	17-Q3	Project Management	3.96
Natural Sciences	4.13	18-Q3	Technical Specialization	3.95
Technical Specialization	4.09	19-Q3	**Social Sciences**	3.81
Engineering Economics	4.07	20-Q3	Interpersonal Skills	3.81
Creativity and Innovation	3.96	21-Q3	Engineering Economics	3.80
Mathematics	3.95	22-Q4	**Humanities**	3.79
Experiments	3.92	23-Q4	Contemporary Issues & Historical Perspective	3.77
Public Policy	3.88	24-Q4	Creativity and Innovation	3.74
Contemporary Issues & Historical Perspective	3.74	25-Q4	**Safety**	3.67
Information Technology	3.71	26-Q4	Attitudes	3.64
Legal Aspects	3.71	27-Q4	Public Policy	3.51
Business and public Administration	3.68	28-Q4	Information Technology	3.41
Humanities	3.67	29-Q5	Globalization	3.26
Social Sciences	3.63	30-Q5	Systems Engineering	3.25
Civic Learning	3.45	31-Q5	Legal Aspects	3.20
Systems Engineering	3.38	32-Q5	Business and public Administration	3.17
Research	3.23	33-Q5	Research	3.10
Globalization	3.17	34-Q5	Civic Learning	2.99

The survey was an opt-in online poll where only those interested voluntarily participated. It was not a controlled experience where participants were randomly selected. Given the responses were in integers, following the rules for significant figures should limit the comparison to the nearest tenth; however, that would be insufficient to show any real distinction. The authors chose to carry out the mean to the nearest hundredth and opted to rank outcomes and group them to develop a relative comparison as those thought most to least important. The authors consider the difference is in the groupings; what one group thought most important is more relevant, than the actual numbers.

Practitioners ranked the following outcomes in the top quintile as most important for pre-licensure: communication, problem recognition and solving, design, professional and ethical responsibility, teamwork, critical and analytical thinking, and risk and uncertainty. Those ranked in the bottom quintile are globalization, research, systems engineering, civic learning, social sciences, and the humanities.

Academia ranked the following outcomes in the top quintile: problem recognition and solving, design, communication, professional and ethical responsibility, mechanics, mathematics, and teamwork. Similarly, those ranked in the bottom quintile are civic learning, research, business and public administration, legal aspects, systems engineering, and globalization.

Comparison of outcomes ranked by practitioners and academia

Practitioners and academics commonly ranked five outcomes in the top quintile: problem recognition and solving, communication, design, professional and ethical responsibility, and teamwork. They also commonly ranked four outcomes in the bottom quintile: globalization, system engineering, research, and civic learning. This indicates that both practitioners and academia share in what they considered the most and least important outcomes for the pre-licensure experience.

The differences in the top quintile between the rankings by practitioners and academia were teamwork and critical and analytical thinking for practitioners whereas academia considered mechanics and mathematics as those listed most important. However, these differences were not dramatic. Practitioners listed mechanics in the second quintile and academics listed both critical thinking and risk and uncertainty in the second quintile.

The one obvious difference among many (marked in bold) is with the mathematics outcome where practitioners listed it in the fourth quintile. One of the authors had the opportunity to discuss the results of the first survey at the 2017 Virginia Engineers Conference in Portsmouth, Virginia in September 2017. In an informal setting, the general discussion concluded that most practitioners did not need advanced calculus or differential equations to perform design calculations in preparation for licensure. However, academics are often using a higher level of mathematics in preparing the civil engineers for higher studies.

Constituent input from second survey

The second survey sought feedback on a proposed restructuring of the outcomes. As noted above, all the BOK2 outcomes were described in the cognitive domain. For this survey the outcomes were divided into two groups, 21 outcomes described in the cognitive domain and seven of these outcomes also described in the affective domain. The affective domain includes objectives that describe changes in interest, attitudes, and values and is an inseparable complement to the cognitive domain.

The revised outcomes in the cognitive domain are: mathematics, natural science, social science, humanities, material science, engineering mechanics, experimental methods and data, critical thinking and problem solving, project management, engineering economics, risk and uncertainty, breath in civil engineering areas, design, technical specialization, sustainable design, communication, teamwork and leadership, attitude, lifelong learning, ethical responsibility, and professional responsibility. Those seven outcomes listed in the affective domain are: sustainable design, communication, teamwork and leadership, attitude, lifelong learning, ethical responsibility, and professional responsibility.

The survey structure was similar to the first survey with one exception. As in the first survey, all of the cognitive domain outcomes are based on six levels of achievement where the affective domain outcomes are based on five levels. There were 156 responses with 28% representing academia, and 72% representing the rest of professionals including practitioners in consulting firms, in governments, construction firms, non-profit organizations, and retirees. This split is nearly identical to the first survey.

The rankings by both practitioners and academia are shown side by side in Table 2 for comparison. There are 21 outcomes divided into quartiles, the first quartile has six outcomes and the remaining quartiles each have five outcomes. The seven affective domain outcomes are ranked separately because it had one less level of achievement and a different mean value. They are not divided in quadrants because there are so few outcomes.

Table 2. Second Survey Rankings of Outcomes by Practitioners and Academia

Practitioners' Response		Rank/ Quar-tile	Academia's Response	
Cognitive Domain Outcomes	**Mean Response**		**Cognitive Domain Outcomes**	**Mean Response**
Critical Thinking and Problem Solving	4.7	1-Q1	Design	5.0
Ethical Responsibility	4.5	2-Q1	Critical Thinking and Problem Solving	5.0
Experimental Methods and Data	4.4	3-Q1	Ethical Responsibility	4.7
Professional Responsibility	4.3	4-Q1	Technical Specialization	4.5
Mathematics	4.2	5-Q1	Mathematics	4.4
Engineering Mechanics	4.2	6-Q1	Communication	4.4
Design	4.1	7-Q2	Professional Responsibility	4.3
Communication	4.0	8-Q2	Engineering Mechanics	4.3
Lifelong Learning	4.0	9-Q2	Teamwork and Leadership	4.1
Material Science	4.0	10-Q2	Material Science	3.9
Attitude	3.9	11-Q2	Experimental Methods and Data	3.9
Teamwork and Leadership	3.9	12-Q3	Project Management	3.9
Technical Specialization	3.9	13-Q3	Engineering Economics	3.9
Natural Science	3.8	14-Q3	Risk & Uncertainty	3.8
Project Management	3.8	15-Q3	Breath in Civil Engineering Areas	3.8
Engineering Economics	3.8	16-Q3	Sustainable Design	3.8
Breadth of Civil Engineering	3.8	17-Q4	Lifelong Learning	3.8
Risk and Uncertainty	3.7	18-Q4	Natural Science	3.8
Sustainable Design	3.4	19-Q4	Attitude	3.7
Social Science	3.0	20-Q4	Social Science	3.5
Humanities	3.0	21-Q4	Humanities	3.4
Affective Domain Outcomes	**Mean Response**	**Rank**	**Affective Domain Outcomes**	**Mean Response**
Ethical Responsibility	4.0	1	Ethical Responsibility	4.2
Professional Responsibility	3.8	2	Professional Responsibility	4.0
Attitude	3.6	3	Communication	3.8
Teamwork and Leadership	3.4	4	Teamwork and Leadership	3.5
Communication	3.4	5	Sustainable Design	3.4
Lifelong Learning	3.4	6	Lifelong Learning	3.4
Sustainable Design	3.0	7	Attitude	3.4

Practitioners and academics commonly ranked three cognitive domain outcomes in the top quartile: critical thinking, ethical responsibility, and mathematics. They also commonly ranked two cognitive domain outcomes in the bottom quartile: social science and the humanities. This indicates that both practitioners and academia share in what they consider the most and least important outcomes for the pre-licensure experience.

The differences in the top quartile of cognitive domain outcomes are what practitioners consider to be experimental methods and data, professional responsibility, and engineering mechanics as most important whereas academia consider design, technical specialization, and communication as most important. However, as in the first survey these differences are not dramatic. Practitioners listed design and communication in the second quartile and academics listed professional responsibility, engineering mechanics, and experimental methods and data in the second quintile.

The ranking of the seven affective domain outcomes are similar with the exception that practitioners ranked attitude considerably higher than the academics. This difference is apparent in the cognitive domain outcomes where practitioners ranked attitude in the second quartile and academics in the fourth quartile. In reviewing the first survey, this difference is apparent but not as pronounced.

What is different from the first survey is that there is no obvious difference. Many of the means of the cognitive domain outcomes in the middle two quartiles are closely ranked. Even outcomes in the bottom two quartiles are the similarly ranked, the only difference being practitioners ranked lifelong learning and attitude in the second quartile. If there is a similarity between the two surveys, it is that practitioners considered attitude more important than academics in both the cognitive and affective domain outcomes.

Conclusions

The results in both surveys indicate that both practitioners and academia share in what is considered to be the most and least important outcomes for the pre-licensure experience. In the first survey, the one obvious difference is with the mathematics outcome. The authors speculate the difference has more to do with the use of mathematics. Most practitioners do not need advanced calculus or differential equations to perform design calculations in preparation for licensure. However, academics are often using a higher level of mathematics in preparing the civil engineer for higher studies. This difference is not apparent in the second survey.

The only apparent difference in the second survey is that practitioners ranked attitude considerably higher than the academics. In reviewing the first survey, this difference is apparent but not as pronounced.

In summary, there is little difference in perceptions between practitioners and academics. If there was a real need to determine a disciplined assessment, the third survey should have been designed to specifically answer this question. However, the authors did not see a need for such a survey and qualitatively concluded that practitioners and academia have similar perceptions.