AC 2010-1096: THE CIVIL ENGINEERING BOK2 AND CHALLENGES TO IMPLEMENTATION IN A PRIVATE UNDERGRADUATE ENGINEERING INSTITUTE

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The Civil Engineering BOK2 and Challenges to Implementation in an Undergraduate Engineering Institute

Abstract

The second edition of the Civil Engineering Body of Knowledge for the 21st Century (BOK2) is a comprehensive, coordinated list of 24 outcomes which define the knowledge, skills, and attitudes expected of the future civil engineer. The BOK2 outcomes use Bloom's Taxonomy for cognitive development to help define the levels of achievement expected to be achieved prior to entry into the professional practice of civil engineering, as well as the levels of achievement for each outcome relative to each stage in the engineer's development, from the baccalaureate degree program, to post-baccalaureate formal education, to pre-licensure working experience. This system clearly identifies the role and responsibilities of the civil engineering profession in the technical and professional development of the future engineer and their ultimate achievement of the BOK.

As part of a continuing effort, ASCE's Body of Knowledge Educational Fulfillment Committee (BOKEdFC) is examining how programs are responding to the BOK2 and possible ways the BOK2 outcomes may be integrated into civil engineering curricula. Previously, the BOKEdFC examined 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. Based on the survey data and analysis, the BOKEdFC concluded that several BOK2 outcomes may be "challenging" for many programs to address in today's civil engineering curricula. These include the nine outcomes shown in Figure 2 (i.e., Outcomes 3 – Humanities, 4 – Social Sciences, 10 – Sustainability, 11 – Contemporary Issues & History, 12 – Risk & Uncertainty, 17 – Public Policy, 18 – Business & Public Administration, 19 – Globalization, and 20 – Leadership). In addition, the committee identified Outcome 5 – Material Science and Outcome 24 – Professional & Ethics as outcomes that may be challenging for programs to fully implement.

The purpose of this paper is to provide a comprehensive analysis of the civil engineering curriculum at Rose-Hulman Institute of Technology with respect to the second edition of the BOK2, or more specifically the BOK2 outcomes associated with the baccalaureate degree since the BOK2 includes outcomes for baccalaureate and post-baccalaureate formal education as well as pre-licensure experience. Specific emphasis is given those BOK2 outcomes that the aforementioned survey data identified as being a challenge for many programs to address within current curricular design. The curriculum, as developed herein, is considered to be in general compliance with BOK2, except that some revisions identified as appropriate to the Mission and Outcomes of the institute have been identified.

Introduction

The first edition of the *Civil Engineering Body of Knowledge for the 21st Century*[1] (BOK1) was released in January 2004. Based on various inputs, a second edition of the *Civil Engineering Body of Knowledge for the 21st Century*[2] (BOK2) was developed and released in February 2008. The BOK1 has already impacted accreditation criteria and civil engineering curricula. The BOK2, while being more recent and not yet addressed within accreditation criteria, is motivating additional change in some civil engineering curricula. Considering specifically the BOK2, a

coordinated list of 24 outcomes is presented within three outcome categories: Foundational, Technical and Professional. The outcomes identify the desired level of achievement defined according to Bloom's Taxonomy for the cognitive domain[3,4]. Additionally, the BOK2 has recommended outcome achievement targets for each portion of the fulfillment pathway: for the baccalaureate degree (B), post-baccalaureate formal education (M/30), and pre-licensure experience (E). The emphasis herein is on those outcomes and achievement targets for the baccalaureate degree.

The BOK2 Outcomes Rubric, using Bloom's Taxonomy, is graphically presented in Figure 1. The reader is cautioned that this is a simple graphical representation of the full rubric only, and should refer to the full rubric as presented in Appendix I of the BOK2 report[2]. What is clearly represented in Figure 1 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 and, for each outcome, the level of achievement (LOA) expected to be fulfilled through the baccalaureate degree (B), the master's degree or equivalent post-baccalaureate formal education (M/30), and pre-licensure experience (E). As already noted, these outcomes and levels of achievement are recommended by ASCE, but have not been adopted in accreditation criteria at the time of this report.

Recently, ASCE's Body of Knowledge (BOK) Educational Fulfillment Committee (BOKEdFC) conducted an analysis of how well civil engineering curricula, in their current design, achieve the educational outcomes of both the first and second editions of the civil engineering BOK[5]. The results of a curricular review by ten representative civil engineering programs were presented along with possible explanations as to why current curricula may fulfill or fall short of fulfilling specific outcomes. Figure 2 presents the results of one of the surveys, specifically one in which programs reported, for the BOK2 outcome rubric, at what level of achievement they believe *all* of the outcome statement is fulfilled by *all* of their baccalaureate ("B") graduates. Shading, font color and cell borders have been provided to assist with visualizing the results of the survey. The BOK2 baccalaureate "B" level of achievement is bounded by a heavy border, and all unshaded cells below the "B" border indicate LOA in which eight or more programs believe all of their graduates are fulfilling the specified LOA. Light grey cells with black font indicate levels of achievement in which five to seven of the reporting programs believe their graduates are fulfilling the specified LOA. Dark grey cells with white font indicate levels of achievement in which four or less programs believe their graduates 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 shaded consistent with the LOA corresponding to shading of the highest "B" level for each outcome.

Based on the survey data and analysis, the BOKEdFC[5] concluded that several BOK2 outcomes may be "challenging" for many programs to address in today's civil engineering curricula. These include the nine "dark grey" shown in Figure 2 (i.e., Outcomes 3 – Humanities, 4 – Social Sciences, 10 – Sustainability, 11 – Contemporary Issues & History, 12 – Risk & Uncertainty, 17 – Public Policy, 18 – Business & Public Administration, 19 – Globalization, and 20 – Leadership). In addition, the committee identified Outcome 5 – Material Science and Outcome 24 – Professional & Ethics as outcomes that may be challenging for programs to fully implement.

The purpose of this paper is to provide a summary of how the civil engineering curriculum at Rose-Hulman Institute of Technology (RHIT) compares with the BOK2 outcomes associated with the baccalaureate degree.

Institutional Profile

Rose-Hulman is an undergraduate-focused engineering college offering baccalaureate degrees in engineering, math, science and economics. RHIT also offers Master's degrees in most departments. Located in Terre Haute, Indiana, RHIT was founded in 1874 and has a population of approximately 1,900 students, the majority of whom are seeking baccalaureate degrees in engineering and are traditional post-secondary learners. The learning experience at Rose-Hulman features a strong emphasis on

- thorough treatment of the theoretical foundations of students' degrees,
- practice-oriented project-based learning,
- highly accessible faculty mentors,
- proactive assistance with internship and career placement, and
- a campus environment with ample opportunities for development of leadership skills, community outreach, and programs to broaden students' perspectives through local, national and international activities.

The Department of Civil Engineering includes approximately 170 students with seven full time faculty members. Every department faculty member holds a professional license or is preparing for professional licensure, and every department faculty member has significant experience in engineering practice. The Department of Civil Engineering is a campus leader in offering real project experiences in its courses and in student service activities. Projects with outside clients are first introduced in the freshman year and culminate with a year-long senior capstone project. Students earn a Bachelor of Science in Civil Engineering upon graduation from the program. Career placement and salaries of department graduates are consistently well above the national average.

RHIT Program Outcomes and Current BSCE Curriculum

The curriculum in the Department of Civil Engineering is in a process of continuous improvement. Feedback from graduating seniors, alumni, and employees of both interns and alumni has been collected by the department for decades and reviewed by the faculty members annually for program improvement. Revision of courses and course content is one outcome of that process, but education of students outside of the formal curriculum has always been a significant part of the learning process. In addition to learning improvement through feedback from constituents, the department remains alert to and active in changes and improvements to engineering education and civil engineering education in particular. Thus, release of the American Society of Civil Engineer's (ASCE) Body of Knowledge (BOK) reports[1,2] were met with great interest by the department, resulting in some curricular revisions due to insights gained from that ongoing dialogue about the appropriate BOK for civil engineering.

The program outcomes at RHIT, shown in Table 1, are in three categories: Technical Knowledge, Professional Skills, and World Citizenship. The Technical Knowledge outcomes are the core of the RHIT education and are developed by each individual department. The Professional Skills and World Citizenship outcomes are institute-wide. Because the Technical Knowledge

outcomes are department-specific, they can vary significantly from one department to another, and may not be structured in the same manner as the institute-wide outcomes. This is somewhat the case for the Department of Civil Engineering. Some of the department outcomes overlap and reference the institute outcomes.

Multiple criterion are associated with each of the outcomes. These criterion were prepared with appropriate consideration of the level of learning appropriate to that outcome for a baccalaureate degree in civil engineering. Rubrics for assessing the level of learning were generally referenced to the guidance of Bloom's Taxonomy, but not strictly so.

RHIT is on the quarter system and a four quarter hour course meets 40 times compared to 45 times for a typical 3-hour semester course. Faculty members strive to cover the same, if not more, content covered in the equivalent three hour semester course. Techniques to accelerate the learning process include:

- identifying lower level learning that students can do on their own and removing that learning from the course meeting time while still holding students responsible, making room for more high level learning in the subject area
- providing a learning environment that features continuous access to faculty with learning centers near faculty offices so students can reduce "wheel-spinning" as they learn and thus make their learning more efficient
- continuous improvement efforts by faculty to make learning as efficient as possible

Because of this learning setting, Rose-Hulman considers a 4-hour quarter course equivalent to a typical 3-hour semester course. The current civil engineering baccalaureate degree requires a total of 194 credit hours, or approximately 48 equivalent courses. Conversion of 48 equivalent courses to a traditional semester system suggests the curriculum is equivalent to 144 semester hours. The curriculum for the department of civil engineering is depicted in Table 2.

Evaluation of Current Curriculum vs BOK2 Outcomes

The current CE curriculum at RHIT was compared to the BOK2 outcomes using several processes:

- **Qualitative reflection** on course and curriculum content by faculty members to identify likely BOK2 compliance
- **Mapping** of RHIT Program Outcomes to BOK2 outcomes and using the results of assessment from the RHIT Program Outcomes to estimate likely BOK2 compliance
- **Surveying** a cross section of students to identify whether they believed they were prepared to successfully complete activities that would demonstrate BOK2 compliance

Qualitative reflection on course and curriculum content was conducted in two independent ways. First, the rubrics for each BOK2 outcome were studied to estimate whether the specified learning was believed to be a formal part of the curriculum. If the learning was believed to be a part of the curriculum, it was then estimated whether a majority of the students would be able to demonstrate the learning specified by the BOK2 rubric. Second, the curriculum was examined on a course-by-course basis. All of the BOK2 outcomes were considered for each course to identify whether learning may occur in the specified outcome not as a formal part of the course

makeup, but due to the unplanned learning facilitated because of the character of the instructor or the types of assignments. For example, the learning objectives of a design assignment may not include development of an understanding of public policy, but use of codes and regulations relevant to the assignment, with discovery of how key concepts and processes therein have impacted the design process, could provide relevant learning about public policy with respect to the BOK2 outcomes. This qualitative reflection, while helpful and insightful, is not direct measurement of outcomes and thus is merely speculation based on extended faculty experience and observations within the curriculum. Even so, the department has high confidence about compliance with BOK2 in some of the outcomes, such as mathematics, science, and design.

Mapping of outcomes for direct measurement was somewhat helpful in this study. The current RHIT Program Outcomes for civil engineering have not been developed in general compliance with either the first or second edition of the ASCE BOK. However, review of the first edition ASCE BOK provided helpful insights when the program outcomes at Rose-Hulman were revised in 2006 and 2007, and some of the first edition ASCE BOK outcomes were adopted, with or without modification, within the Department of Civil Engineering. Similarly, some of the BOK2 program outcomes were adopted from BOK1. The criterion for those outcomes could be mapped almost directly from the RHIT Criterion under a specific Program Outcome to the BOK2 outcome rubric. Other RHIT Program Outcomes were very similar to some BOK2 outcomes and could be mapped with some confidence. Assessment of the RHIT program outcomes has been under way since 2008, so early data is available from that assessment, permitting direct measurement of some compliance with BOK2 outcomes. The data from this exercise is not presented in this paper in the interest of brevity. This mapping exercise was performed after completion of the above qualitative reflection. In general, comparison of the qualitative assessment with the direct measurement indicated the qualitative assessment was generally conservative with respect to identifying whether students could demonstrate learning in compliance with BOK2 outcomes.

Although a **survey** is not direct measurement, it is some indication of whether learners believe they have the knowledge specified in the questions submitted. Although the RHIT civil engineering department highly values learning in the humanities, social sciences, and historical and contemporary issues to develop well educated professionals, the department does not facilitate formal learning about why these are important to civil engineering. This learning is simply essential to being a well educated leader, regardless of their significance to engineering, so this specific learning is not taught or assessed in the program. Thus, this study was curious about whether students thought they could demonstrate learning consistent with the BOK2 outcomes in these areas, which specifies that students express application of these areas to civil engineering. A survey was used to address this question.

During the fall quarter of 2009, the junior class was asked to complete a survey featuring four questions about humanities, social sciences, and historical and contemporary issues. The students were asked to identify how confident they were that they could demonstrate learning in compliance with the BOK2 outcome in these areas on a five point scale, with a score of five if they were certain they could demonstrate and a score of one if they were certain they could not. Forty-one of forty-six students in the class completed the survey. The results are shown Table 3. The findings indicate about 78% of the juniors are at least somewhat confident they can

demonstrate BOK2 learning in the humanities and in historical and contemporary issues. About 67% are at least somewhat confident they can demonstrate BOK2 learning in the social sciences.

Based mostly on the described qualitative reflection and mapping, a graphical comparison of Rose-Hulman's Department of Civil Engineering with the BOK2 outcomes was prepared and is presented in Figure 3. As with Figures 1 and 2, the bold line identifies the level of learning to be demonstrated to meet the BOK2 outcomes. Dark shaded areas of the figure identify where less than half of the students likely to be able to demonstrate that level of learning in the outcome. Lightly shaded areas identify where more than half of RHIT's students, but less than 80% are believed to be likely to demonstrate that level of learning in the outcome. Unshaded areas identify where it is believed more than 80% of RHIT's students could demonstrate acceptable learning at the specified level. Light grey shading only was also used for some of the learning beyond the BOK2 "B" level where it was believed 50% or more of the students could successfully demonstrate learning.

Current Curriculum and the "Challenging" BOK2 Outcomes

As previously described, earlier studies of curricula compliance with BOK2 identified some particularly challenging BOK2 outcomes. These were identified because multiple programs expressed preliminary concern about whether student learning could generally achieve the level of learning identified for those outcomes in BOK2. These were Outcomes 3 – Humanities, 4 – Social Sciences, 10 – Sustainability, 11 – Contemporary Issues & History, 12 – Risk & Uncertainty, 17 – Public Policy, 18 – Business & Public Administration, 19 – Globalization, and 20 – Leadership.

At Rose-Hulman, BOK2 Outcomes 19 – Globalization and 20 – Leadership were not found to be problematic. This conclusion was supported by assessment data already being collected for the similar RHIT Program Outcomes 18 – Leadership and 22 – Cultural and Global Awareness. Leadership has been a program strength at RHIT for years, and recent university-wide initiatives have been successful in the areas of Cultural and Global Awareness. BOK2 Outcome 12 – Risk & Uncertainty, is not included in the Department of Civil Engineering Technical Knowledge Outcomes. The sophomore year Statistics for Engineers course facilitated by the Department of Mathematics imparts strong fundamental statistical skills, but those skills are not directly linked to later civil engineering coursework. Structural and water resources courses in the department also make use of risk and uncertainty principles, but it is not certain BOK2 outcomes can be satisfied in this outcome to the level suggested by BOK2.

The other reported "challenging" outcomes: Outcomes 3 – Humanities, 4 – Social Sciences, 10 – Sustainability, 11 – Contemporary Issues & History, 17 – Public Policy, and 18 – Business & Public Administration are valued by the department and university and the faculty believe appropriate learning is taking place in all of these outcome areas. However, this study found the specified learning defined by the BOK2 outcome rubrics may not be demonstrated by the students. The differences in some cases were minor. For example, the university greatly values learning in the humanities, social sciences, and historical and contemporary issues. In fact, because Rose-Hulman does not have degree programs in the humanities and social sciences, a Department of Humanities and Social Sciences exists specifically for the education of the

mathematics, science and engineering students to learn humanities and social sciences. That department features an exceptional group of faculty with a firm commitment to broadening the education of technically oriented students and RHIT strives to assure a broad education for the students in these areas. This is judged a program strength. However, Rose-Hulman is committed to learning in these areas in looking outward to the broader knowledge and good of humankind, rather than how these areas relate specifically to engineering. Failure to meet the standard in BOK2 is judged by the faculty to be because RHIT is striving for non-centric learning outward into the arts, literature, languages and society, rather than inward to the technical fields of engineering, math and science. Rose-Hulman believes this is striving for a higher standard appropriate to professionals and leaders.

In the area of sustainability, the Department of Civil Engineering considers sustainable design to be a fundamental design criterion that should infiltrate all design work where appropriate, along with safety, economy, constructability, aesthetics, durability, and others. Thus, sustainable design is a consideration wherever appropriate in traditional engineering design, and students are expected to assess sustainability of a design based on the science, processes, and accepted standards of sustainable development. It is possible this study's assessment of student learning in this area is conservative, but because sustainability is not currently assessed in the program, it seemed inappropriate to conclude a majority of students could satisfy the BOK2 outcomes rubrics at the higher levels.

In summary, Rose-Hulman's assessment of their expected student performance in most of the previously identified challenging outcomes is similar to that found in the prior study. In most of these cases, however, this was not a matter of neglect but rather of setting priorities. Because of the short, intermediate, and long term success of many of its graduates not only as engineers but also in business and management, RHIT judges its current curriculum to provide a relatively successful balance. However, what has worked historically may not continue to work well for graduates of Rose-Hulman Institute of Technology in the future, and transition to a curriculum that is more in compliance with the BOK2 guidance may be appropriate.

Curricular Changes Needed to Fully Implement the BOK2

Clearly, full implementation of the BOK2 at Rose-Hulman would require sacrificing learning in one area to accommodate learning in another. This study estimated that satisfaction of the BOK2 outcomes would require the equivalent of one to two courses, or 4-8 quarter hours of learning, to properly address the revised BOK2 outcomes. At RHIT, learning in the fundamentals is considered essential, and there is little opportunity to trim credit hours in math, science, or basic engineering topics to maintain BOK2 compliance anyway. Rose-Hulman also values breadth in the CE education and demands heavier than typical preparation in a broad range of civil engineering design areas. This may be characterized as strong breadth in the civil engineering baccalaureate. Thus, sacrificing some required CE courses that assure breadth and substituting courses in business and public administration, sustainability, or similar is not a desirable option even if BOK2 and ABET compliance could be maintained by doing so. Rose-Hulman's civil engineering graduates often find themselves in advanced design positions shortly after graduation. The technical specialization that is possible because of the accelerated quarter-based curriculum permits the students to extend their baccalaureate education into technical

specialization after achieving a broad civil engineering foundation. It has been estimated that students who carefully plan their technical specialization course work and who enter as freshmen with some college credit may complete course work comparable to up to 50 percent of a Master of Science (MS)-level course sequence before graduation with their BS. This feature is also highly valued in the program. It is thus likely the curricular changes needed to fully implement the BOK2 at Rose-Hulman Institute of Technology would be in the elimination of or reduction in learning in basic engineering areas such as electrical circuits, thermodynamics, or chemical processes or material science. This course work is currently in the fall and winter terms of the 3rd year, shown in Table 2.

The BOK2-Compliant Curriculum

This study will not recommend a specific BOK2-compliant curriculum. Due to its small size, quarter-based curriculum and engineering-focused Mission, RHIT has a decided advantage over other universities. Rose-Hulman will continue to work closely with its alumni, boards, and friends to evolve towards the future of the civil engineering profession to assure the lifelong success and leadership of its graduates. Some parts of that evolution will likely resemble the BOK2 more and more, but other parts may not.

Were it necessary, due to accreditation, to implement a BOK2-compliant curriculum, the department faculty and CE Board of Advisors would set priorities and make necessary adjustments. If BOK2 implementation is required before most states require MS or equivalent knowledge for licensure, RHIT would not likely sacrifice the curriculum's technical specialization that is available over the broad CE knowledge base. The department could examine trimming multiple classes by one credit hour, from four to three, to make room for the new learning. Another alternate would be to sacrifice learning in the areas of basic engineering topics outside civil engineering (electrical circuits, thermodynamics, chemical processes or material science), as noted above. Some combination of these two options could also be considered. However, learning in electrical circuits, thermodynamics, chemical processes or material science is fundamental to better decision-making in the area of sustainable development and energy. This is important to the future of civil engineering practice. Knowledge in these areas is also valuable for passage of the Fundamentals of Engineering (FE) Exam. It is thus possible that such changes could result in lower passage rates for the FE exam and weaker preparation in areas of future need for the civil engineering profession.

If BOK2 compliance were not necessary until most states also require the MS or equivalent for licensure, Rose-Hulman would likely sacrifice one or two technical specialization courses since its graduates would likely move immediately on to MS specialization after earning their BS. In that event the CE Department at RHIT would have already taken action to provide a professional MS to allow its own graduates to continue through RHIT's program for an accredited degree.

Conclusions

The curriculum and learning in the Rose-Hulman Department of Civil Engineering is in general compliance with the outcomes of BOK2. However, some of the BOK2 outcomes would require strengthening to assure compliance. Curriculum revision would likely require elimination or

modification of one to two courses (4 to 8 credit hours). While setting priorities in its curriculum, the Department of Civil Engineering would have to make some difficult choices to reduce learning in basic areas that could weaken preparation for future work in sustainable design and energy, and also reduce preparation for success in the Fundamental of Engineering Exam.

Bibliography

1. ASCE Body of Knowledge Committee of CAP^3. 2004. *Civil Engineering Body of Knowledge for the 21st Century: Preparing the Civil Engineer for the Future,* Reston, VA, January. (http://www.asce.org/raisethebar).

2. ASCE Body of Knowledge II Committee of CAP^3. 2008. *Civil Engineering Body of Knowledge for the 21st Century: Preparing the Civil Engineer for the Future,* Second Edition, Reston, VA, January. (http://www.asce.org/raisethebar).

3. ASCE Levels of Achievement Subcommittee of CAP^3. 2005. *Levels of Achievement Applicable to the Body of Knowledge Required for Entry Into the Practice of Civil Engineering at the Professional Level,* Reston, VA, September. (http://www.asce.org/raisethebar)

4. Bloom. B. S., Englehart, M. D., Furst. E. J., Hill, W. H., and Krathwohl, D. 1956. *Taxonomy of Educational Objectives, the Classification of Educational Goals, Handbook I: Cognitive Domain.* David McKay, New York, NY.

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

Figure 1: Graphical Representation of the BOK2 Outcome Rubric

OUTCOME #	OUTCOME TITLE	BLOOM'S LEVEL OF ACHIEVEMENT (LOA)					
		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	Problem Recognition & Solving	10	9	9	2	1	0
9	Design	9	10	9	8	7	0
10	Sustainability	6	3	2	2	0	0
11	Contemporary Issues & History	7	3	2	1	0	0
12	Risk & Uncertainty	7	3	2	1	0	0
13	Project 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

Figure 2: Number of Programs (out of 10) Reporting *All* of the BOK2 Outcomes at Each LOA are Likely Fulfilled by *All* of Their Baccalaureate Graduates.[5]

Table 1: Rose-Hulman's BSCE Program Outcomes	
Professional Skills	
1	**Leadership** means successfully motivating and enabling a group towards the achievement of a shared, articulated goal.
2	**Teamwork** requires cooperative effort toward a common goal wherein each individual contributes in a particular role while subordinating personal interests.
3	**Communication**, regardless of the media, requires unique skills whether communicating with individuals or with groups.
World Citizenship	
4	**Cultural and Global Awareness** requires perception and understanding of the cultural perspectives and social systems that define human communities
5	**Ethics** requires the use of appropriate moral theories, ethical principles, or professional standards to weigh alternatives and determine a proper professional course of action.
6	**Service** is the use of one's time and skills to benefit an individual or community without cost to the recipient.
Technical Knowledge	
Graduates will demonstrate the ability to ***perform essential engineering functions***.	
7	**Technical Core** – Solve problems in mathematics (through differential equations), probability and statistics, calculus-based physics, chemistry, and an additional area of science.
8	**Experiments** – Design an experiment or experimental program to meet a need; conduct civil engineering experiments, and analyze and interpret the resulting data.
9	**Engineering Problems** – Develop problem statements and solve well-defined engineering problems in four technical areas appropriate to civil engineering.
10	**Engineering Impact** – Explain the impact of engineering solutions on the economy, environment, political landscape, and society; apply principles of sustainability to design of engineered systems.
11	**Contemporary Issues** – Explain the impact of historical and contemporary issues on the identification, formulation, and solution of engineering problems.
Graduates will demonstrate the ability to ***design/construct complex engineering systems***.	
12	**Design** – Design a system or process in more than one civil engineering context to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, constructability, and sustainability.
13	**Multidisciplinary** – Function effectively as a member of a multidisciplinary team.
14	**Professional/Ethical** –Analyze a situation involving multiple conflicting professional and ethical interests to determine an appropriate course of action; explain the importance of professional licensure (also see Outcome 5 under World Citizenship above).
15	**Communication** – (see Outcome 3 under Professional Skills above).
16	**Engineering Tools** – Apply relevant techniques, skills, and modern engineering tools to solve engineering problems.
Graduates will demonstrate their ***potential for technical leadership and management***.	
17	**Life Long Learning** – Explain the need for and demonstrate the ability to learn on their own, without the aid of formal instruction.
18	**Leadership** – (see Outcome 1 under Professional Skills above).
19	**Service** – (see Outcome 6 under World Citizenship above).
20	**Project Management** – Explain key concepts in project management, and develop solutions to well-defined project management problems.
21	**Business and Public Administration** – Explain key concepts and processes used in business, public policy, and public administration.
22	**Cultural and Global Awareness** – (See Outcome 4 under World Citizenship above)

Table 2. Rose-Hulman's Bachelor of Science in Civil Engineering Curriculum					
Year, Semester or Quarter	Course (Department, Number, Title)	Category (Credit Hours)			
		Math & Basic Sciences	Engineering Topics (Check if contains significant Design)	General Education	Other
Year 1					
Fall	MA 111 Calculus I	5			
	PH 111 Physics I	4			
	RH 131 Rhetoric and Composition			4	
	EM 104 Graphical Communications		2		
	CLSK 100 College and Life Skills				1
Winter	MA 112 Calculus II	5			
	PH 112 Physics II	4			
	Elective (HSS)			4	
	CE 110 Computer Applications and GIS		4		
Spring	MA 113 Calculus III	5			
	EM 103 Introduction to Design		2 (✓)		
	EM 120 Engineering Statics		4		
	CE 101 Engineering Surveying I		2		
	Science Elective	4			
Year 2					
Fall	MA 221 Dif Eqns & Matrix Algebra	4			
	CHEM 105 Engineering Chemistry I	4			
	EM 202 Dynamics		4		
	Elective (HSS)			4	
	CE 201 Engineering Surveying II		2		
Winter	MA 222 Dif Eqns & Matrix Algebra II	4			
	EM 203 Mechanics of Materials		4		
	Elective (HSS)			4	
	CHEM 107 Engineering Chemistry II	4			
Spring	MA 223 Statistics for Engineers	4			
	EM 301 Fluid Mechanics		4		
	CE 210 C.E. Computer Applications		2		
	CE 320 C.E. Materials		4		
Year 3					
Fall	CE 321 Structural Mechanics I		4 (✓)		
	CE 336 Soil Mechanics		4 (✓)		
	ECE 206 Elements of Elec Eng. or CHE 201 Cons Princ and Balances		4		
	CE 371 Hydraulic Engineering		4		
Winter	ME 201 Thermodynamics or CHE 202 Basic Chem Process Calc		4		
	CE 441 Construction Engineering		2		
	CE 432 Concrete Design I		3		
	CE 471 Water Resources Engineering		4		
	Science Elective	4			
Spring	CE 310 CE Numerical Methods		2		
	CE 431 Steel Design I		3 (✓)		
	CE 460 Environmental Engineering		4		
	CE 461 Environmental Engineering Lab		2		
	RH 330 Tech and Prof Communication			4	

Table 2. Rose-Hulman's Bachelor of Science in Civil Engineering Curriculum - Continued					
Year 4					
Fall	CE 489 CE Design & Synthesis		2 (✓)		
	Technical Elective		4		
	CE 450 C.E. Codes & Regulations		4		
	Elective (HSS)			4	
	Elective (HSS)			4	
Winter	CE 489 CE Design & Synthesis		4 (✓)		
	CE Technical Elective		4		
	Technical Elective		4		
	CE 303 Engineering Economy		4		
Spring	CE 489 CE Design & Synthesis		2 (✓)		
	Technical Elective		4		
	Elective (HSS)			4	
	Elective (HSS)			4	
	CE 400 Career Preparation Seminar				0
TOTALS - ABET BASIC-LEVEL REQUIREMENTS		51	106	36	1
Overall Total Hours for Degree		194			
PERCENT OF TOTAL		26.3%	54.6%	18.6%	0.5%

Table 3. Student perceptions on their own knowledge about humanities, social sciences and historical and contemporary issues.

		Number of classes				
	Average	5 or more	4	3	2	1
How many college level humanities and social science classes have you completed, not including foreign language classes?	3.8	16	12	9	6	2
		How confident?				
	Average	Certain I could do so	Somewhat confident I could do so	Neutral	Doubtful I could do so	Certain I could not do so
		5	4	3	2	1
Under the subject of Humanities, the ASCE BOK expects civil engineering students to be able to be able to demonstrate the importance of the humanities in the professional practice of engineering. If asked to discuss this in one or several paragraphs, how confident are you that you could do this?	4.0	11	24	8	2	0
Under the subject of social sciences, the ASCE BOK expects civil engineering students to be able to demonstrate the incorporation of social sciences knowledge into the professional practice of engineering. If asked to discuss this in one or several paragraphs, how confident are you that you could do this?	3.8	10	20	10	5	0
Under the subject of contemporary issues and historical perspectives, the ASCE BOK expects civil engineering students to be able to explain the impact of historical and contemporary issues on the identification, formulation, and solution of engineering problems and explain the impact of engineering solutions on the economy, environment, political landscape, and society. If asked to discuss this in one or several paragraphs, how confident are you that you could do this?	4.0	14	21	7	3	0

OUTCOME #	OUTCOME TITLE	BLOOM'S LEVEL OF ACHIEVEMENT (LOA)					
		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	Problem Recognition & Solving	B	B	B	M/30		
9	Design	B	B	B	B	B	E
10	Sustainability	B	B	B	E		
11	Contemporary Issues & History	B	B	B	E		
12	Risk & Uncertainty	B	B	B	E		
13	Project 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	
17	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 3: Graphical Comparison of Rose-Hulman's BSCE Program Level of Achievement to BOK2 Outcomes