



Implementation of a Civil Engineering High-Impact Learning Practice (HILP) Requirement in Support of ASCE Body of Knowledge (BOK) Outcomes

Dr. Kelly Brumbelow, Texas A&M University

Dr. Kelly Brumbelow is an Associate Professor in the Zachry Department of Civil & Environmental Engineering and the Director of Interdisciplinary Engineering Program Development at Texas A&M University. He has been a faculty member at Texas A&M since 2002, where his technical specialty is water resources engineering, planning, and management. Prior to this position, he completed his undergraduate and graduate studies at Georgia Tech, where he taught undergraduate courses for 7 years. His professional activities have included projects in East Africa, Central America, the Middle East, Alaska's North Slope, and throughout the "lower 48 states." His current activities at Texas A&M include a wide range of activities with particular emphasis on development of novel interdisciplinary curricula, courses, and experiences.

Dr. Luciana R. Barroso, Texas A&M University

Luciana R. Barroso, Ph.D., is an Associate Professor of Structural Engineering in the Department of Civil and Environmental Engineering, in the College of Engineering at Texas A&M University. She currently also serves as the Director of Undergraduate Services and Chair of the Curriculum and Implementation Team for the department. Luciana has been with Texas A&M University since 1999, and in that time has taught a wide range of courses ranging from the freshman to graduate levels. She has been active in academic program and curriculum development from the department level to the university level, where she served as co-chair of the Quality Enhancement Plan (QEP) committee that determined the academic course of actions to be taken over the next accreditation cycle to address critical issues related to enhancing student learning. She has received funding for her engineering education research from the Department of Education FIPSE program and from the National Science Foundation (NSF) CCLI program. She also has been involved in several professional developments that were provided by the Aggie STEM Center to Texas ISD teachers. Her research interests include structural health monitoring and control, structural dynamics, earthquake engineering, and engineering education.

Greg Stadter, Texas A&M University

Greg Stadter received a BS degree in Biology from Texas A&M University in 2008 and a MA degree in Global Leadership from Fuller Theological Seminary in 2018. Greg is an academic advisor II for the Zachry Department of Civil and Environmental Engineering at Texas A&M University. Previously, Greg was an academic advisor for the College of Science and Engineering at Texas State University and worked in college ministry for 9 years before moving into higher education.

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Abstract

A large civil engineering department has added a formal curriculum requirement for the BS degree that students participate in a high-impact learning practice (HILP) in support of ASCE Body of Knowledge (BOK) outcomes. This requirement evolved from a holistic curriculum transformation process structured around the ASCE BOK version 2; that process postulated that several BOK outcomes underrepresented in coursework (often labeled the “challenging outcomes”) could be addressed through HILPs at the approximate midpoint of the BS curriculum. The curricular requirement was instituted in the 2016-2017 academic catalog as a “zero credit hour course” that could be satisfied through a number of civil-engineering focused activities meeting the high-impact learning requirements, such as internship, co-op work semester, study abroad, service learning, undergraduate research, directed studies, co-curricular leadership, and any other experience nominated by a student and approved by the department. The placement of the curricular requirement at the midpoint of the BS degree was purposely selected to ensure students had a solid technical foundation prior to the experience and would have the opportunity to apply some of the knowledge gained to their senior-level courses. The first full cohort of students has recently completed the HILP requirement, providing insight into what the students are gaining from this new requirement.

The department’s experience in implementation offers several useful lessons for others considering a similar requirement. Specifically, several components are necessary: a clear statement of the need and desired outcomes of the requirement; a well-considered process and system for documentation and assessment; proactive publicity and advising of students to include the requirement in their degree planning; communication to external stakeholders who may mentor students in their HILPs; faculty and staff buy-in to cooperatively administer the requirement; and an appropriate set of rubrics for individual student evaluation, among others. While possible HILPs include several experiences, the overwhelming majority of students participated in summer internships, a sign of a strong job market during the period of study. Student deliverables include: completion of a survey on the importance of each of the BOK2 outcomes in the student’s HILP and the student’s sense of preparedness in each outcome, narrative documentation of the student’s experience using the supplementary experience record form required for PE licensure application in the department’s home state, and a reflective essay addressing at least three BOK2 outcomes identified earlier as typically underrepresented in coursework. Preliminary analysis of these deliverables has determined that students find HILPs particularly impactful in addressing the BOK2 outcomes “problem recognition and solving,” “lifelong learning,” and “attitudes,” as evidenced by their frequent choice of these outcomes in their reflective essays. The least frequently chosen outcomes were “globalization,” “social science,” and “contemporary issues and historical perspectives,” suggesting less achievement in these outcomes through this cohort’s chosen HILPs.

Introduction: Background and Motivation

The civil engineering profession has long focused on the educational issues and needs related to the practice of the profession. As part of this continued process, the American Society of Civil Engineers (ASCE) convened a “Summit on the Future of Civil Engineering” in 2006 that looked at articulating an “aspirational global vision for the future of civil engineering” [1]. This also served as a guide to updating the ASCE Body of Knowledge document, which “offers guidance for the education and training programs of private and public organizations that employ civil engineers; and supports changes in licensure requirements” [2]. The document provides guidelines on the learning outcomes deemed important for the profession.

During the 2013-14 and 2014-15 academic years, Texas A&M University’s civil and environmental engineering department undertook a curriculum transformation project, basing its program learning outcomes on the 2nd Edition of the ASCE Body of Knowledge (BOK2). This process inherently included an emphasis to move beyond “what courses does a civil engineering major take” to “what can a civil engineering student major *do*” and what skills are needed to carry out these tasks [4]. This project provided a mechanism for a holistic approach to the curriculum and explicitly developed a curriculum map, connecting the learning outcomes to specific courses [5, 6]. Among many outcomes of this process was the identification of gaps in the curriculum, where learning outcomes were not as strongly addressed as desired. Some learning outcomes are difficult to achieve within the constraints of formal academic settings, which has been previously noted from surveys conducted by the ASCE BOK Educational Fulfillment Committee (BOKEdFC) [7].

High-Impact Learning Practices (HILP) have received the attention of higher education institutions due to a developing case of benefits in student engagement, success, and persistence. In 2007, the Association of American Colleges and Universities (AAC&U) published the *College Learning for a New Global Century* report and found several promising “high-impact” activities including first-year seminars, common intellectual experiences, learning communities, service learning, undergraduate research, study abroad, internships, and capstone projects, among others. This report recommends that institutions prioritize HILPs to enhance student engagement and increase student success. Specifically, institutions are encouraged to offer every student the opportunity to participate in two HILPs during an undergraduate program to increase the effectiveness of higher education [8].

In 2012, Texas A&M University (TAMU) created a Quality Enhancement Plan (QEP) to “purposefully engage [our students] in high-impact learning experiences and thoughtfully reflect on their learning experiences in order to develop the habits and skills for integrative and lifelong learning” [9]. Kuh’s research [8] is cited within the QEP multiple times as part of the reason TAMU wants to make the shift to enhancing the prevalence of HILPs. TAMU’s goal from the QEP is to create a culture where engagement in HILPs is the norm for students. As part of the university community, and in an effort to create that culture, the TAMU Department of Civil and Environmental Engineering implemented a “zero credit hour course” (CVEN 399) into the 2016 course catalog that would require students to participate in a HILP in order to complete the Bachelor of Science in Civil Engineering (BS-CVEN) degree.

The newly created CVEN 399 zero-credit course, due to the nature of high-impact activities, provided a mechanism to address those difficult to achieve learning outcomes. This approach also provides a formal mechanism for collection of assessment data. While students in the department have historically had high participation in internship experiences, for example, there was no formal mechanism to capture that information. Study-abroad opportunities have been growing, but their impact and connection to specific learning outcomes, such as globalization, had not been explicitly assessed. Requests for tracking student HILP experiences were made by university administration and were tied to the university's QEP process. The course mechanism allows for HILP experiences to be formally recorded and to evaluate their connection to program learning outcomes. The course was placed at mid-curriculum, to ensure students had a significant foundation in civil engineering fundamentals in order to best capitalize on their experience. This also resulted in the student being able to bring the knowledge and skills gained through their HILP experience into senior level courses. This had the added benefit of introducing another major assessment opportunity at mid-curriculum, to supplement the existing efforts at the time of graduation.

Over the past two years, this course has produced quantitative and qualitative data to assess learning outcomes through students' survey responses and reflections. Analysis of these data will help evaluate the overall efforts of the QEP and furthermore should provide high quality, wide-ranging data to fill in gaps in the literature on what different HILPs can achieve in the engineering education context, specifically. Much literature exists in overarching STEM and science education areas; however, the engineering education literature is more limited in number and scope of studies. Pierrakos et al. investigated undergraduate research experiences (URE) for engineers and found that most studies "have focused on the sciences, whereas undergraduate research experiences in engineering are limited." They recruited 22 engineering URE programs to study student gains vis-a-vis ABET-derived outcomes [10]. Other publications have likewise focused on single HILPs. Tener et al. studied an internship program in an undergraduate construction engineering and management program [11]. Peters [12] and Hahn et al. [13] investigated study abroad programs at two different institutions, respectively. Other authors have assessed HILPs at the course (rather than curriculum) level [14, 15]. A few more expansive studies have reviewed student perceptions of HILPs and associated pedagogy [16] and post-graduation impacts [17], but these have still been limited by an absence of structured and obligatory participation at the curriculum scale.

HILPs may be powerful tools for engineering educators to help students achieve key learning outcomes. This paper will present the implementation and results of a curricular requirement for HILP participation and its attendant performance for specific learning outcomes from the Civil Engineering BOK2. Hopefully, other universities and departments will be able to use this information to help make informed decisions on what HILPs they want to encourage or require and the learning outcomes that would result from the experience.

Implementation of a Required HILP in the Curriculum

TAMU's civil and environmental engineering department added a required HILP for all BS students starting with the 2016 academic catalog (i.e., BS students entering the university in the fall 2016 semester and later). The requirement was formalized as a "zero-credit hour course":

CVEN 399 Mid-Curriculum Professional Development. This structure has many advantages but does require some degree of planning and coordinated execution, which we describe in detail here.

Embodiment of the activity requirement as a class allowed for specific placement in the curriculum sequence, which was important from the driving considerations of the “gap” in coverage of some BOK outcomes in the middle portion of the BS curriculum. Specifically, CVEN 399 was placed in the spring term of the third year, which is at the transition from the early portion of the curriculum composed of prescribed basic courses required of all civil engineering students (e.g., statics, fluid dynamics, mechanics of materials, etc.) to the later portion where students choose tracks and electives to specialize in various sub-disciplines. Therefore, the prerequisites for CVEN 399 are all of these early required courses (eight in total). An additional consideration is that the department has had a historical issue with some students taking courses out of sequence (e.g., a student interested in structural engineering might jump ahead to senior-level courses in that area and defer the required junior-level fluid dynamics course to the last semester), which causes difficulties in course scheduling and ensuring all students can take all required courses to graduate on time. Therefore, CVEN 399 was itself made a prerequisite to the senior-level professional practice and capstone design courses to act as a scheduling “gateway” in the curriculum. In terms of student learning processes, this sequencing presses students to reflect on the target BOK outcomes with fundamental knowledge of civil engineering, but not advanced knowledge.

The zero-credit hour course is transcribed and a graduation requirement. However, because it carries no credit hours, it does not incur tuition or fees for students, and it does not increase the total number of required credit hours in the curriculum, which is typically a significant concern for university oversight bodies and senior leadership. At TAMU, zero credit hour courses can require deliverables of students, but workload is expected to be very light, and courses are generally graded as pass/fail. Students may satisfy the HILP requirement with one of seven standard activities (internship, co-op work semester, study abroad, service learning, undergraduate research, directed studies, and co-curricular leadership) or they may suggest an alternate activity to be approved by the faculty overseeing the CVEN 399 course that term. As discussed below, the great majority of students take the course in conjunction with an internship in the summer between the third and fourth year.

The novelty of the HILP requirement and its implementation as a zero-credit hour course have required an enhanced level of attention on student advising. The department maintains a library of online advising materials housed in the university learning management system (LMS). A short video on CVEN 399 (approximately 10 minutes) was produced to explain course rationale and processes as part of this library. Students are required to meet with a faculty or staff advisor each semester before registration, and annual degree plan revisions are required by the university. Together, these measures have yielded a low rate of students failing to complete the course appropriately, on par with other required courses in the curriculum.

Management of the course each semester is handled by a faculty member who is assisted by a committee of other faculty and advising staff in the summer term due to the especially high enrollment then. The course has no meetings and is managed exclusively through the campus

online LMS, allowing students to complete the requirements and deliverables asynchronously at any location -- a particular concern for students studying abroad or working at internships far away from campus. The course begins with a pre-approval process for the student's HILP and mentor supervising the HILP experience. A form stating the student's planned activity, its relevance to civil engineering education and practice, the mentor's name and contact information, and including the mentor's signature is due the first day of class. This quality control step ensures that all activities are consistent with the course and curriculum goals. Students are required to engage in the HILP in the semester they take CVEN 399; retroactive (or anticipated) credit for activities in other semesters is not allowed. At this time, no minimum period of engagement (e.g., hours, days, or weeks or work) has been defined, but the pre-approval process does consider quality and quantity characteristics of the HILP experience. Proposals deemed unsatisfactory are returned to the student for revision or clarification (e.g., undergraduate research on a non-engineering topic is disallowed and the student is encouraged to begin research with an engineering faculty member); if revisions do not yield a satisfactory proposal, the student is dropped from the course and advised on how to prepare an acceptable HILP in the following semester. After pre-approval is completed, the student has no academic obligations until the final deliverables at the end of the semester.

The three final deliverables are due to the instructor one week before the start of final exams each term. These deliverables include:

1. A survey for the student to assess her/his level of preparedness for the HILP in each of the 24 BOK2 outcomes and the importance of each outcome in the student's particular HILP experience. This survey begins the process of self-reflection on the BOK outcomes and provides assessment data for the department's continuous improvement process at the mid-curriculum point.
2. A completed Supplementary Experience Record (SER) form, which is part of the Texas Board of Professional Engineers (TBPE) application package for professional engineering (PE) licensure in the state. This requirement familiarizes students with the PE application process and encourages them to form a habit of completing SER forms at the conclusion of a period of work while memories are still fresh. The SER format requires a factual, action-driven narrative, which is distinct from the reflective and context-driven writing piece described next.
3. A reflective essay focusing on at least three of nine specified BOK2 outcomes (attitudes, business and public administration, contemporary issues and historical perspectives, globalization, lifelong/self-directed learning, problem recognition and solving, project management, risk and uncertainty, and social science). As described above, these outcomes were found to have gaps in reinforcement in the midsection of the department's curriculum. Outcome-specific prompts are supplied to assist students in their reflective process, but the prompts all follow the DEAL model of reflection ("Describe, Examine, and Articulate Learning") [18] where students focus on what they've learned, why the learning is important, and how the learning affects their futures.

Deliverables are evaluated using standard rubrics by the course instructor (in fall and spring) or a member of the evaluation committee (in summer). Rubrics are oriented toward performance of the required work, but not necessarily quality or depth of that work; that is, a reflective essay that exhibits shallow or misdirected learning can be as equally valid for course completion as one that shows a career-changing experience. The key concern is for authentic and conscientious work on the deliverables; this is an important course characteristic in light of the varying quality of HILP mentoring and experiences outside the control of the academic faculty. Deliverables deemed unsatisfactory are returned to the student with a one-week opportunity for a single revision. If all three deliverables (including revisions) are satisfactory, the student receives a grade of “pass.” If unsatisfactory deliverable(s) are not revised to an acceptable level in the one-week period, the student receives a grade of “fail,” and must repeat the course.

Inter-session courses -- e.g., “May-mester” study abroad courses -- typically require special handling by the course instructor with modified schedules on all course steps. Thankfully, enrollment in these cases has not yet been overwhelming.

Data on Implementation Thus Far

A total of 181 students have taken and completed the CVEN 399 course to date in the summer 2018, and spring, summer, and fall 2019 terms, respectively, with another 22 students taking the course in spring 2020; term-by-term enrollments are shown in Table 1. The completed student count represents the approximately three-quarters of the cohort of students starting in fall 2016 who are on-track to graduate in the traditional four academic years. The remaining quarter of the cohort is expected to complete the course in time for fall 2020 graduation with a large number working internships in summer 2020.

Table 1. Student Count by Semester and HILP Type

HILP Type	Summer 2018	Spring 2019	Summer 2019	Fall 2019	Spring 2020	HILP Total
Internship	6		133	2	6	147
Co-op work semester					3	3
Study abroad	1	8	8	1	6	24
Service learning			1		1	2
Undergraduate research	1	4	3	6	5	19
Directed studies				2		2
Co-curricular leadership				2		2
Other			3		1	4
Semester Total	8	12	148	13	22	203

As can be seen in Table 1, three-quarters of students undertake an internship or co-op work semester as their HILP, a sign of a very strong job market during this period, with summer internships being the majority of all HILPs. While this majority share was expected prior to implementation, the data thus far also suggest that a desire for a diverse range of HILP opportunities and timings is appreciated by the student body and maintains robustness against potential weak job markets in the future. It should be noted that these data reflect only HILP participation to fulfill the CVEN 399 course. Many students engage in multiple activities during their BS programs that are not documented here.

The specific BOK2 outcomes chosen by students for their reflection essays suggest where student learning is most pronounced. Reiterating the description of these essays from above, students must select a minimum of three outcomes from a list of nine possibilities. Tables 2 and 3 present data on the number of outcomes upon which students chose to reflect and which outcomes were chosen by all students and students in specific HILPs with larger numbers of participants, respectively. These data support multiple interesting findings.

First, data in Table 2 show that about 20% of all students voluntarily chose more than the minimum number of outcomes for reflection. As these choices entailed extra work for the students in writing their essays, this suggests some appreciable measure of an “inspiration effect” of HILPs. Students learned so much, and were so excited about their learning, that they elected to undertake extra work in a zero credit hour, pass/fail class (i.e., there is no effect on a student’s GPA from the class, and standards for passing are not necessarily very high).

Second, the efficacy of HILPs in promoting learning vis-a-vis BOK2 outcomes is not uniform. Mathematically, a random draw of outcomes for each student essay (with only the minimum required number of three chosen) would yield selection rates of 33.3% in Table 3. Selection over and under this rate suggests more or less marked learning, respectively, in each outcome. Values in bold italics are appreciably higher than the benchmark rate, suggesting high efficacy.

Table 2. Student Count by Number of BOK2 Outcomes Chosen for Reflective Essays

Number of BOK2 Outcomes Chosen	Number of Students
3 (minimum)	144
4	23
5	7
6	3
7	1
8	0
9	3

Table 3. Portion of Students Choosing Each Possible BOK2 Outcome

BOK2 Outcome	All HILPs (N=181)	Internship Only (N=141)	Study Abroad Only (N=18)	Undergraduate Research Only (N=14)
Problem recognition and solving	70.0%	74.3%	29.4%	71.4%
Lifelong/self-directed learning	63.3%	62.1%	52.9%	85.7%
Project management	51.1%	59.3%	23.5%	14.3%
Attitudes	51.7%	50.7%	47.1%	64.3%
Business and public administration	30.0%	35.7%	17.6%	7.1%
Risk and uncertainty	27.2%	27.9%	17.6%	35.7%
Contemporary issues and historical perspectives	16.7%	10.0%	64.7%	14.3%
Social science	13.9%	12.1%	17.6%	21.4%
Globalization	10.0%	3.6%	70.6%	7.1%

Numbers in bold italics indicate significant selection over expected rates from a random draw (33.3%). Other HILP types not shown due to small numbers of students engaged in them.

Third, specific HILPs have differing levels of efficacy for specific outcomes. While it was not unexpected that study abroad students chose “globalization” at a high rate, the significance of that high rate is even more pronounced compared to the very low rates for internship and undergraduate research students. Especially surprising is the parallel for “contemporary issues and historical perspectives,” high rates of choice for study abroad students but very low for others. This finding, while preliminary, suggests that blanket HILP requirements may not be totally effective at reinforcement of large numbers of learning outcomes, and more specific mapping of HILP activities to outcomes is needed.

Fourth, in contrast to the finding immediately above, some BOK2 outcomes do seem to be robust across HILP experiences. Specifically in this dataset, it is noted that “lifelong/self-directed learning” and “attitudes” were overselected in all cases.

Overall, student work on the required deliverables was completed at a high level of quality with low rates of unsatisfactory deliverables requiring revision. Table 4 presents rates at which first submissions of each deliverable were graded as unsatisfactory and sent back to students for revision. Notes are also provided on typical reasons for the grading. The most common issue was failure to write the SER narrative according to TBPE instructions (which require first-person,

Table 4. Rates of Unsatisfactory Deliverable Submissions

Deliverable	Rate of Unsatisfactory First Submissions	Typical Reasons for Unsatisfactory Work
BOK2 Outcome Survey	0.6%	Survey not completed
TBPE SER Form	12.2%	Narrative not written according to TBPE instructions; Missing signatures
Reflection Essay	7.2%	Essay did not include reflection and only re-stated TBPE SER narrative; Essay did not address chosen BOK outcomes

action-oriented statements of engineering work). While this indicates students' lack of attention to instructions, it is a useful lesson for these students for future licensure applications. To date, all students have been able to revise deliverables to acceptable levels and pass the course in their first attempt.

A final issue that emerged over the implementation should be noted concerning the relationship of the university department to off-campus HILP mentors. As part of the quality control process, the department requires that each student have a mentor supervising her/his HILP and cognizant of its role in satisfying an academic requirement. The mentor signs the pre-approval form at the start of the semester and the TBPE SER at the end. There were a few cases of potential mentors expressing concern that the university would burden them with work as part of the CVEN 399 course. Materials have been revised and communications with off-campus partners have gone out to ensure others that no work is expected beyond the two signatures and a general level of supervision consistent with good professional practice.

Strategies and Considerations for Implementation Elsewhere

The implementation strategy of a zero credit hour course may not be available at all institutions. A few possible alternative strategies for an HILP requirement are shown in Table 5 along with strengths and weaknesses of each approach. Regardless of the exact mechanism used to implement an HILP requirement, the following questions can be useful for a program considering how it wishes to do so:

- *What exactly do we wish to achieve by requiring an HILP?* TAMU's objective was to reinforce learning on specific BOK2 outcomes. Others may wish to focus on research experience, global awareness, networking to aid in eventual job searches, or other objectives.
- *What should be the prerequisite knowledge and experience before the HILP, and for what should the HILP itself be a prerequisite?* Without a clear understanding of sequencing of the HILP in the degree plan, students will likely request credit for experiences ranging

Table 5. Alternative Required HILP Implementation Strategies

Strategy	Advantages	Disadvantages
0 Credit Hour Class (implemented at TAMU)	No additional tuition for students; avoids limitations on adding credit hours; allows prescribed sequencing; clearly understood as graduation requirement	Not possible at all institutions; novel idea that requires careful explanation and advising
1 Credit Hour Class	Possible at all institutions; allows prescribed sequencing; grading can be incorporated into continuous improvement process; clearly understood as graduation requirement	Program may not have ability to add required credit hour to curriculum; drawing credit hour from other courses may be difficult/contentious
Non-curricular requirement¹	No additional tuition for students; avoids limitations on adding credit hours	Commonly used for graduate degrees (e.g., thesis defenses), but not as common for undergraduate degrees; harder to implement sequencing; not available at all institutions
Assignment in Existing Class²	Least disruptive to existing curriculum; No additional tuition for students; allows prescribed sequencing; links HILP learning to later course(s)	Added faculty workload in the existing class; need clear policy of whether students can pass existing class if HILP not completed successfully
“Honor System” Completion³	Could encourage feeling of student ownership of requirement; least workload for program faculty/staff	Non-compliance issues are likely; difficulty in gathering assessment data

Notes:

¹ A “non-curricular requirement” is a requirement for degree conferral that is not tied to a transcribed class. At the graduate level, preliminary exams and thesis defenses are examples of non-curricular requirements. At all program levels, minimum grade point averages are also non-curricular requirements.

² An example of this strategy would be to require the deliverables from the HILP (reflection essay, etc.) be submitted as the first assignment in the capstone design course or some other course.

³ By “honor system” completion, we mean that students would be expected to fulfill the requirement, but no formal degree requirement would exist.

from high school up to the term of graduation. However, what students gain from HILPs will be different at different stages of their BS degree programs.

- *What types of HILPs should be eligible?* The selection of specific HILP types is, of course, largely driven by the program’s objectives in requiring them. However, forethought on how these types can vary widely will help with the many proposals that

students will make. For example, if undergraduate research is allowed, should that research be restricted to: engineering topics, civil engineering topics, STEM topics in general, etc.? For students working internships, should they be required to work in a traditional face-to-face office scenario, or are remote work assignments acceptable? Should HILP supervisors be licensed PEs? If study abroad experiences are allowed, will programs without engineering courses be included?

- *How will the HILP be approved and how will it be evaluated?* Ownership of the HILP requirement by one or more faculty is an essential aspect of an HILP requirement. Like other degree program aspects, this includes responsibility and integrity for quality control through approvals and assessments.

Summary and Conclusions

The department's experience in implementation offers several useful lessons for others considering a similar requirement. Specifically, several components are necessary: a clear statement of the need and desired outcomes of the requirement; a well-considered process and system for documentation and assessment; proactive publicity and advising of students to include the requirement in their degree planning; communication to external stakeholders who may mentor students in their HILPs; faculty and staff buy-in to cooperatively administer the requirement; and an appropriate set of rubrics for individual student evaluation, among others. While possible HILPs include several experiences, the overwhelming majority of students participated in summer internships, a sign of a strong job market at the time the HILPs studied here were completed.

Preliminary analysis of the deliverables for the course suggests that students find HILPs particularly impactful in addressing the BOK2 outcomes "problem recognition and solving," "lifelong learning," and "attitudes," as evidenced by their frequent choice of these outcomes in their reflective essays. The least frequently chosen outcomes were "globalization," "social science," and "contemporary issues and historical perspectives," suggesting less achievement in these outcomes through this cohort's chosen HILPs. It is important to note that HILPs do not appear to be uniform in their applicability to the chosen BOK2 outcomes, which suggests that a strategy of multiple and targeted HILPs may be needed to address a large number of learning objectives. However, the value of HILPs has been demonstrated by the "inspiration effect" whereby an appreciable number of students performed work beyond course minimums.

Analysis of the data produced by the CVEN 399 course and HILP requirement continues and will be presented in the near future. Specifically, analysis of student reflection essays will be conducted to investigate student learning in greater depth, and demographic issues will be assessed to determine if student choice of, or access to, specific HILPs correlates with individual characteristics, even when HILP participation is mandated.

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