The Journey to Initial Accreditation of a Civil Engineering Program

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The Journey to Initial Accreditation of a Civil Engineering Program

Abstract

Starting a new engineering program that fulfills ABET EAC 2000 requirements is a major undertaking. With a new program, there is great responsibility to develop the curricula and assessment tools to meet university, community, and stakeholder requirements while meeting ABET EAC outcomes. In this paper, the authors will discuss the process of implementing a new civil engineering program at West Texas A&M University in Canyon, Texas (in the Amarillo, Texas metropolitan area). This discussion includes the planning, launch, and implementation of curricula that lead to a successful initial ABET EAC accreditation, as these events occurred over a five-year period (2010 – 2015). The authors will describe the curriculum, development of courses and laboratories, the senior design capstone, and preparation of the self-study report necessary for accreditation. All curricula and assessment tools are linked to a modified Bloom's Taxonomy and ABET Outcome 3 Criteria a through k. A description of the university, its service area, and student population is also provided. In 2015 West Texas A&M University achieved a major milestone through designation as a Hispanic Serving Institution (HSI, 25% or more of student population) [1] and is seeking to improve participation of women and underserved populations in STEM fields, such as civil engineering. Lessons learned and future improvements for the civil engineering program at West Texas A&M University are provided, which include curricular revisions, implementation of a unique approach to the senior design capstone, a continual assessment and improvement process, self-study preparation, and other insights and reflections.

Introduction

West Texas A&M University (WTAMU) is one of eleven universities comprising the Texas A&M System, enrolling nearly 10,000 undergraduate and postgraduate students as of Fall 2016 [2]. WTAMU has established undergraduate programs in mechanical (2003), civil (2010), and environmental engineering (2012). These programs were joined with existing engineering technology (BS and MS programs) and computer science programs. University realignment added mathematics to these programs and formed a new standalone School of Engineering, Computer Science, and Engineering (ECSM) in Fall 2015. ECSM has expanded to 665 students as of Fall 2015, of which over 500 are engineering and engineering technology majors. Growth has been rapid since 2003 but the school still maintains a very hands-on and personable approach to instruction with faculty instructing all lectures and most laboratory courses.

WTAMU features a large proportion of first-generation and non-traditional students that comprise about 50% of the total student population. ECSM enrolls about 50% of its students through transfers from partner institutions including Amarillo College [3], South Plains College [4], Lubbock Christian University [5], and Wayland Baptist University [6]. The transfer credits align fairly closely with the pre-engineering program at WTAMU, as described in the Curriculum section of this paper. WTAMU further requires that at least 39 credit hours of junior and senior level courses be taken in residence at the university in order to earn a degree from the institution.

The engineering faculty at ECSM includes five full-time mechanical engineering, two full-time civil engineering faculty, two full-time environmental engineering, one full-time engineering technology faculty, and one full-time engineering instructor. All required coursework for the civil engineering major is covered by the ECSM faculty.

Civil and environmental engineering function together as a group within ECSM in regard to curriculum planning and teaching coursework for all courses with a civil engineering specific designation. ABET and ASCE prefer that civil and environmental engineering faculty to be licensed in order to teach any course with significant design content, typically reflected in the course title and catalog description. The civil engineering faculty members are currently licensed as professional engineers while the environmental engineering faculty members are licensed or in process of professional licensure as of the start of the fall 2016 semester.

The Need for New Engineering Programs

Currently, thirty-two public and private universities in Texas graduate approximately 10% of all engineering students in the USA, about 65,000 current students in total as of January 2016. Those Texas institutions graduated over 10,000 BS, MS, and PhD engineering students in 2014 [7]. As the population of the USA and Texas grows, there is growing demand for engineers as well. The Texas Higher Education Coordinating Board (THECB) notes that since 2000, more than 540,000 additional students have been added to Texas universities, including a doubling of enrollments for Hispanics and African Americans [8]. The Texas Office of the State Demographer notes that the 2015 population of 27 million will grow to somewhere between 31 million (no migration, natural growth only) to 54 million (migration following 2000-2010 US Census trends) [9], spurring a strong demand for Texas institutions of higher learning to graduate more engineers. In particular, civil engineers are at the forefront of development, construction, and maintenance of the infrastructure that society is dependent upon.

The State of Texas has been adding new engineering programs in the 21st century, as approved through the Texas Higher Education Coordinating board (THECB). Examples include authorization of civil engineering undergraduate programs at WTAMU (2010) [10], Tarleton State University (2014) [11], Texas Southern University (2015) [12], and Angelo State University (2015) [13]. The US Bureau of Labor Statistics is forecasting an 8% increase from the current 281,000+ civil engineers nationwide between 2014 and 2024 [14], equating to 23,000+ more positions added to that total. The need is real and the planning as discussed in this paper is essential.

Curriculum

The civil engineering curriculum was developed to be consistent with the outcomes of ABET 2000 [15], the ASCE Body of Knowledge [16], and an engineering advisory panel of regional stakeholders. The original civil engineering program proposal was submitted to the Texas Higher Education Coordinating Board and was approved to begin in fall 2010.

The civil engineering program was structured with operational similarity to the existing mechanical engineering program. The two programs share synergies in lower division coursework and naturally complement each other in terms of shared faculty as well as laboratory and classroom resources.

WTAMU uses a pre-engineering sequence that corresponds approximately to the first two years of undergraduate instruction. This pre-engineering sequence is approximately the same as an associate's program in engineering that exists at Amarillo College [17] and South Plains College [18], partner community colleges that provide a substantial number of transfer students to WTAMU. This system also gives flexibility to students who are interested in engineering to explore which engineering major is the best fit for him or her.

The pre-engineering sequence consists of fundamentals of engineering (ENGR 1301), computer-aided drafting (ENGR 1304), statics (ENGR 2301), dynamics (ENGR 2302), calculus I (MATH 2413), calculus II (MATH 2414), chemistry I (ENGR 1411), and chemistry II (ENGR 1412) with a GPA of 2.75 or better. WTAMU and partner institutions with articulation agreements described in the Introduction section generally follow the Texas Common Course Numbering System (www.tccns.org) system [19] that uses common numbering for freshman and sophomore level courses, further simplifying the transfer credit process. When the pre-engineering sequence is complete, the student can declare civil engineering as his or her specific major.

The civil engineering major is 127 semester credit hours. The state of Texas is pushing all four-year programs toward 120 credit hours unless an absolute need can be shown, as with engineering programs, for more credit hours. The university required core curriculum is 42 hours (e.g. English, speech, history, government, math, natural science, etc.). Engineering is allowed to use higher requirements for math (e.g. calculus I instead of algebra) and natural science (e.g. calculus physics instead of general physics). There are 66 credit hours in required math, natural science, and general engineering course work plus required coursework in six traditional civil engineering sub-disciplines (structural, transportation, construction, geotechnical, water resources, and environmental). The current checklist shows 18 credit hours of electives (now 19 credit hours due to a change noted in section on Response to the ABET EAC Visit). Of the electives, nine credits are for three upper division electives in civil engineering which must have one structural design (e.g. steel, concrete, etc.), one in design of any subarea, and one is a general open elective in any subarea. The balance of ten hours fall into a math/physics elective, a general engineering elective, and a biology course. A degree checklist is updated periodically and available for review online [20].

Civil engineering courses use a four digit format with the first number is student level (1 – 4), the second is semester credit hours, the third digit is sub-area, and the fourth digit is a final index. The third digit is generally assigned as follows in the table below.

A few examples of course numbers following the convention in Table 1 include CENG 2331 (introduction to environmental engineering), CENG 3321 (civil construction materials), and the structural elective CENG 3352 (concrete design).

Table 1: Civil Engineering Sub-Area Course Numbering Convention

Sub-Area	Third Digit
Water resources	1
Construction	2
Environmental	3
Geotechnical	4
Structural	5
Transportation	6
Senior Design	8
Undergraduate Research and Internship	9

Development of Coursework and Laboratories

Rolling out the civil engineering curriculum was fairly straight forward because the existing mechanical engineering and engineering technology programs share the core education requirements and freshman/sophomore coursework with civil engineering. In fact, mechanical engineering and civil engineering share approximately 80 credit hours of coursework in total. Thus, only civil engineering specific coursework was new but this still was a minimum of twelve new courses that total 37 credit hours. This course work was rolled out in waves as follows.

The first wave occurred in spring 2010, just before civil engineering officially launched in fall 2010. Two courses were offered as engineering special topics courses for which virtually any pre-engineering, mechanical engineering, and engineering technology students could enroll. The two courses were introduction to environmental engineering (without a lab) and surveying (with a lab). These two courses were to become the two required sophomore level civil engineering courses.

The second wave consisted of required junior level civil engineering courses that other majors could also take, provided that they had the required prerequisites. The courses were civil construction materials, structural analysis I, geotechnical engineering, and transportation engineering. This arrangement allowed for other engineering majors to easily switch to the new civil engineering major.

The third wave consisted of upper division civil engineering coursework. These courses included steel and concrete design, hydrology and hydraulics, water and wastewater design, civil engineering research, civil engineering internship, and civil engineering design. With the roll out of the third wave, the first civil engineering students graduated in summer and fall 2013 and triggered the ABET EAC accreditation process.

The fourth and final wave is refinement. A new civil/environmental engineering fluid mechanics that included open channel flow replaced the mechanical engineering fluid mechanics course. A lab was added to the introduction to environmental engineering course. More civil engineering electives were added, such as structural analysis II and structural dynamics. Course prerequisites were revised and tightened for the required civil engineering courses, completing the roll out of the civil engineering curriculum in the space of four academic years.

Senior Design

The first civil engineering senior design course was held in summer session 2013. The reasoning for a summer session was to ensure that among the seven participating students, most if not all would have completed coursework in all six traditional subareas (structural, transportation, construction, environmental, geotechnical, and water resources) of the civil engineering discipline.

This first senior design project entailed the design of an outdoor civil engineering laboratory. The project was linked to the ABET EAC 2000 Outcome 3c and modified Bloom's Taxonomy described in the section of this report in regard to preparation for accreditation.

The students arranged themselves in six subarea teams, each of which had at least three students involved. This means that any one particular student was part of two or more of the smaller subarea teams. One student was chosen by the other students to be the project leader, who in turn organized meetings and met with the three faculty members that were in charge of the course.

The students had approximately seven weeks to design the outdoor civil engineering laboratory. At first glance, that may not sound like enough time, but most of these students were taking only the senior design course in summer. It was much like a 40-hour-a-week job in scope, a fairly reasonable and realistic scenario for the students.

Students were responsible for weekly meetings and work summaries that were submitted to the faculty in charge. Along with evaluation of an interim report with presentation and a final report with presentation, peer and faculty evaluation forms were completed for all seven students. This allowed for a final grade to be assigned to each student for his or her performance in the course. Six students were deemed to have passed with a grade of C or better. While it may sound harsh for the seventh student deemed below this threshold, it is very important for program integrity and the safety of the public that a student performing below an acceptable level not graduate until he or she demonstrates the high level of competence required in the civil engineering discipline.

The senior design project was very important from the standpoint that the graduation of the first cohort of civil engineering students triggered the year-long process for ABET accreditation of the program. An honest assessment of this project, the students, and the faculty involved is necessary for the integrity and growth of the program. This format of senior design was deemed a success from the faculty standpoint and was used as a similar model for the subsequent senior design class with eight students in summer 2014. Program evaluators noted that the format was unique and yet sufficient from the standpoint of what is necessary to graduate competent civil engineers.

Preparation for ABET EAC Visit

Preparation for an initial visit requires a vast amount of time and buy-in from the faculty. This self-study consists of nine different criteria which were compiled into a 270-page document prepared during the spring and early summer of 2014. The faculty that prepared this report spent dozens of hours working independently and in a team setting, poring over each detail in the self-study report and documentation for each course. An excellent view from the evaluator standpoint describes this preparation process, stating that a program really only gets one chance to make a good impression and that involvement of faculty and documentation are key for gaining or maintaining accreditation[21].

In addition to the self-study, faculty were also required to prepare materials for the accreditation visit. There were two major components—course binders and senior design videos. The course binders consisted of materials from selected courses taken by civil engineering students. The binders consisted of sample work (i.e. homework, exams, quizzes, and design projects) for the accreditation reviewers. The sample work was assessed by faculty to determine how well the student met metrics as discussed by the civil and environmental engineering faculty. Copies of the two senior design final presentations were placed on flash drives for the reviewers upon request. Videos of the senior design presentations were also made available for review as well.

The assessment metrics were tied directly to ABET EAC 2000 Outcome 3c a-k with achievement tied to a modified Bloom's Taxonomy at a freshman, sophomore, junior, or senior level. The levels of achievement, in order of increasing difficulty are: knowledge - recall and organization of facts and figures; understanding - comprehending the meaning of facts and figures; application - being able to utilize appropriate formulas and principles to determine a problem solution; synthesis - being able to break a problem into components and solve by application of basic principles without reliance upon example problems; and design - making something that is new and unique with little reliance upon examples.

The ABET accreditation site visit occurred in October 2014. The reviewers were provided access to the self-study materials, met with faculty and administrators, and conducted focus group sessions with current civil engineering students. The comment and response period was completed by October of 2015 with an initial accreditation of three years awarded [22].

Response to the ABET Visit

The initial visit was positive. Two of the faculty in charge of the accreditation preparation had also been involved with a prior visit for the mechanical engineering program. ABET EAC formal accreditation training for the team leader was extensive and was very helpful for preparation of documentation. The resulting report was far more thorough at 270 pages in length plus large binders of information for each course. As result, only two concerns needed addressing.

The first concern was for laboratory equipment. From the onset of the civil engineering program, laboratory equipment has been added as noted earlier in this paper. As the program rolled out, equipment was secured for surveying, civil materials, geotechnical engineering, and fluid mechanics. More equipment has been procured for civil materials and faculty are currently building up the introduction to environmental engineering laboratory course with a large purchase of equipment at the start of the fall 2015 semester.

The other major concern was to require a third natural science course in the curriculum. Chemistry and physics, each with two courses, are integral to the curriculum. It was determined that biology could be used as that third science course. Fortunately for this accreditation cycle, transcripts for all six initial graduates indicated that the students had taken a biology course. For all current and future students, an immediate curriculum change was instituted to require biology. In the future, the third science course may be changed to a list of approved science topics such as biology, geology, or another science other than chemistry or physics.

Conclusions and Recommendations

The state of Texas has been proactive in response to the needs of stakeholders, business, and society for training an increasing number of engineers. Developing new engineering programs in the 21st century requires this input and a willingness of faculty to adapt and change in order to develop the problem solving skills that engineering students will need.

The civil engineering faculty decided to implement a continuous improvement program to gather assessment data. Courses will be on a regular cycle for assessment to address problems and change curriculum more quickly, as needed. Making continuous improvement a part of the ECSM culture will ensure the best education for engineering students.

The October 2014 ABET visit affirmed the good aspects of the civil engineering program and spurred the faculty to move quickly to address deficiencies, especially to implement a third required science with biology, even before the comment and response period is complete. The new environmental engineering program will also directly benefit from the learning process, much like the civil engineering program learned from the first WTAMU ECSM accredited program in mechanical engineering.

Newer programs such as the ones at WTAMU have great flexibility in devising and implementing engineering education. Established programs can learn from and share best practices with these newer programs. In any case, the criteria of ABET and the ASCE Body of Knowledge give guidance in regard to what education of engineers in the 21st century should address and the feedback to continually improve and innovate.

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