Collaboration between a Civil Engineering and an Environmental Engineering Program: Better Together

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Abstract

The civil engineering and environmental engineering programs at West Texas A&M University (WTAMU) (a mid-sized regional institution in the Texas A&M University System and located in the Amarillo, TX region) are collaborating on curriculum and senior design capstone projects in order to strengthen one another and boost student enrollments in shared courses and in the majors overall. The BS degree in civil engineering program began in 2010, followed later by the BS environmental engineering program in 2013. As such, the curriculum of the latter was re-aligned to that of the former to share curriculum, lab space, faculty, and other resources. This paper will highlight this alignment and the process by which a shared senior design capstone was undertaken such that it would satisfy program outcomes and lead to ABET EAC accreditation. The lessons learned from the authors can be utilized by other universities that are adding one or both of the civil and environmental engineering programs to their institutions. These ideas may also work with pairs of related but separately administered engineering majors (e.g. civil and mechanical, mechanical and aerospace, mechanical and biomedical, chemical and petroleum, electrical and computer, etc.).

Introduction

West Texas A&M University (WTAMU) is a member of the Texas A&M University System, enrolling approximately 10,000 undergraduate and postgraduate students [1]. WTAMU began offering engineering programs in 2003 in response to industry needs for the greater Texas Panhandle region. WTAMU houses five engineering related programs (civil, electrical, environmental, mechanical, and technology) in its College of Engineering. Current enrollment in the College of Engineering as of Spring 2020 for all bachelor's and master's students is approximately 624, far exceeding original program goals of 150 students forecast in 2003. The civil engineering program began in 2010 and has gone through two ABET accreditation cycles since the first graduates in 2013. The environmental engineering program launched with its first students in 2014 and graduated its first students in 2018, which triggered its first ABET self-study submission in 2019.

WTAMU is a Hispanic serving institution [2] with about 50% of its incoming students either transfer students from partner universities or junior colleges and/or are first generation university students in their immediate families. Favorable tuition rates for instate and students from other

US states has seen the university grow its population by about 28% from 2010 to 2018 [3] in a metropolitan area where population growth was only about +0.37% [4].

There are two civil engineering and two environmental engineering faculty in WTAMU's College of Engineering. These faculty members are responsible for planning and teaching all civil and environmental engineering courses in the college. The objectives of this paper will discuss how these faculty members have developed and aligned their engineering programs with the ultimate aim of synergizing efforts and growing both programs in both enrollment and academic quality.

Civil and Environmental Engineering Undergraduate Programs by Number

A query of ABET accredited civil and environmental engineering undergraduate programs as of 2019 was conducted. It shows that there are at least 252 accredited civil engineering programs and 74 accredited environmental engineering programs in the USA. Many civil engineering programs have been continuously accredited since 1936 (especially for traditional land-grant institutions and older private universities) when ABET began accreditation for engineering programs. The oldest accredited environmental engineering program dates to 1966 at Rensselaer Polytechnic Institute in New York. The majority of accredited environmental engineering programs have occurred since the 1990's, 68 of the 74 universities (94%). A summary search online yields approximately 87 undergraduate environmental engineering programs, several of which will soon be seeking ABET accreditation [5].

In the state of Texas, there are five undergraduate environmental engineering programs. These are located at Southern Methodist University, Tarleton State University, Texas A&M University – Kingsville, West Texas A&M University, and the University of Texas at Austin (began in Fall 2017). The first three universities on this list have gone through one or more successful accreditations for their environmental engineering programs. West Texas A&M University will seek accreditation for its environmental engineering program in Fall 2019, to be the fourth accredited program in the state. In Texas currently the need for engineers is greater than ever as the state population grew from 25.1 to 29.5 million between 2010 and 2020. [6].

Curriculum

Rolling out engineering programs from scratch is an arduous process, especially in the 21st century. The engineering programs began in stages at WTAMU with approval from the Texas Higher Education Coordinating Board (THECB). Since an engineering technology program was already in place, a mechanical engineering program was added in 2003. Students can earn an associate's degree in engineering or science at the partner institutions [7, 8, 9, 10] and transfer to WTAMU [11]. The civil engineering program was added in 2010 and shares a large number of lower division courses with the mechanical engineering program. When the civil engineering program was added, the majority of the lower division courses in engineering were renumbered to match the Texas Common Course Numbering System (TCCNS) that is also used by the partner junior colleges, making transfers even simpler [12].

Environmental engineering started in 2013 as a separate bachelor's degree program. Several civil engineering courses (introduction to environmental engineering, fluid mechanics, and water resources) were renumbered and reconfigured to share with the environmental engineering program. The two programs share lower division courses and naturally complement each other in terms of shared faculty as well as laboratory and classroom resources.

WTAMU uses a pre-engineering sequence that approximates the first two years of study at a four year institution and is approximately the same as the pre-engineering (associate's degree) program at partner junior colleges and universities. It was decided to make the pre-engineering sequence identical for both civil and environmental engineering BS programs in 2019. Students must complete 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 (CHEM 1411), and chemistry II (CHEM 1412) with a GPA of 2.75 or better. When the pre-engineering sequence is complete, the student can declare civil or environmental engineering as the specific major and take major sequence courses in those fields.

The civil and environmental engineering majors are approximately 125 to 127 semester credit hours, depending on selected electives. The state of Texas desires for all four-year programs to be approximately 120 credit hours unless there is a demonstrable need for more credit hours, as with engineering programs, when accreditation is involved. WTAMU required core curriculum is 42 hours (e.g. English, speech, history, government, math, natural science, etc.). Engineering has higher requirements for math (e.g. calculus I instead of algebra) and natural science (e.g. calculus physics instead of general physics), versus most other four-year degree programs. The balance of credit hours (approximately 83 to 85), are selected in accordance with ABET EAC criteria to cover lower (common) and upper (discipline specific) engineering courses, mathematics (calculus I/II/III and differential equations), required natural sciences (calculus physics and chemistry I/II), and other natural sciences (primarily biology and geology). The degree checklists are updated periodically and available for public usage.

Development of Shared Coursework and Laboratories

The coursework for both the civil and environmental engineering programs was phased in as students completed the pre-engineering sequence or transferred from junior colleges to enroll in the programs. The civil engineering program initially shared all lower division general engineering courses with mechanical engineering, including fundamentals of engineering, computer aided-drafting, statics, dynamics, mechanics of materials, fluid mechanics, engineering economy, and engineering ethics. Civil and mechanical engineering also shared the fluid mechanics course. There was also a partial alignment of the civil engineering materials course with the existing materials course for mechanical engineering and engineering technology students in order to share lab activities and resources.

Civil engineering also initiated three new courses with labs: surveying, geotechnical engineering, and introduction to environmental engineering. Each of these labs required procurement of

equipment and development of the course and lab materials. All of these courses were offered to mechanical engineering students as elective credit, helping to boost enrollments.

Environmental engineering is configured as a stand-alone BS program. While most lower division engineering classes are shared with civil engineering, there is less synergy in the stand-alone environmental BS degree as compared to an environmental specialization track within a civil engineering program. The faculty did align a new fluid mechanics course for civil and environmental engineering, the introduction to environmental engineering course, and the water resources course for both programs. The environmental engineering program has several unique upper division courses of which several are available with cross-listing with civil engineering (such as water and wastewater treatment) or as open electives to other engineering students.

Senior Design

Senior design is a capstone experience that is used as part of the overall assessment to determine if undergraduate students are ready for employment or graduate school. This capstone experience is meant to summarize and combine all of the previous coursework, which itself is developed in accordance with the ABET EAC Criteria [13].

In regard to the ABET EAC criteria, the civil engineering discipline is overseen by the American Society of Civil Engineers (ASCE) and must emphasize at least four of six areas of concentration: structural, transportation, geotechnical, construction, water resources, and environmental while also considering sustainability, business, ethics, and other issues of practice. The environmental engineering discipline is overseen by a consortium of organizations that includes the American Academy of Environmental Engineers and Scientists (lead organization), ASCE, ASME, AIChE, and other organizations. Environmental engineering curriculum must include "more than one major environmental engineering focus area, (e.g., air, water, land, environmental health); design environmental engineering systems that include considerations of risk, uncertainty, sustainability, life-cycle principles, and environmental impacts," according to the ABET EAC. Thus, both programs have significant shared requirements that can be addressed together in the senior design experience.

It is a natural fit to have environmental engineering students work with civil engineering students in senior design. The first collaboration with civil and environmental engineering in fall 2017 had (seven civil and one environmental) students design a LEED certified (Leadership in Energy and Environmental Design) [14] mixed use residential and business land development project. The second collaboration in fall 2018 (three civil and three environmental) students were involved in the development of building, drainage, and wastewater collection and treatment improvements for the WTAMU campus. A third collaboration in fall 2019 (five civil and one environmental) students designed a tiny home development for persons transitioning out of homelessness in the Amarillo area. In all collaborations, the environmental engineering student(s) enhanced the water resources, environmental, and sustainability aspects of the capstone projects, subject areas which had been weak points for the civil engineering students. It is envisioned that these collaborations will continue with the two programs during the senior

design capstone, as both programs have similar requirements and needs to demonstrate competence as prescribed by ABET EAC criteria.

Preparation for the ABET EAC Visit

Preparation for an ABET accreditation visit requires a vast amount of time and preparation by the faculty. The initial accreditation study for civil engineering was completed for a visit in Fall 2014 [15]. As described in depth in Leitch et al, the self-study materials were prepared and tied to assessment metrics derived from ABET ECS 2000 Outcome 3c 1-7. Many readers will be familiar with this process, which is well-known.

The assessment techniques developed first for mechanical engineering were effective for that program to achieve initial ABET EAC accreditation and reaccreditation in 2006 and 2012, respectively. However, these techniques were inadequate when the civil engineering accreditation sought initial accreditation, as it was very difficult to follow and mapped outcomes to the ABET EAC criteria in a complicated manner. The two environmental engineering faculty started in Fall 2013 and were asked to join the civil engineering faculty to develop a more streamlined assessment process in 2014 for the initial accreditation of the civil engineering program. This was successful, with initial accreditation granted in 2015.

The new assessment process was adopted by mechanical engineering, with both the civil and mechanical engineering programs successfully completing the ABET EAC process for 2018. Encouraged by this success, all four engineering programs at WTAMU (civil, mechanical, environmental, and electrical) will use the same process for ABET accreditation. Since the four programs share many common courses between them, the extra work to re-accredit civil and mechanical engineering is incremental to the initial accreditation studies for environmental and electrical engineering and will also simplify the visit schedule for ABET accreditation officials to come all at once for all of the programs in 2024.

Conclusions and Recommendations

In January 2019, the civil and environmental engineering faculty met to discuss implementation of further synergies. Three initiatives that will be implemented from this is the use of tracks in the two programs (an initiative themed on course selection), cross-listing more upper-level courses between the two programs (a curricular change), and promotion of elective courses to students in each program via persuasive communication strategies.

The first initiative will see the civil engineering major promote a general/structural track and an environmental/water resources track. The environmental engineering major will promote general, civil engineering, and mechanical engineering tracks. This will not require extra coursework but can encourage students in one major potentially taking three courses in a related engineering major. It is not necessarily a minor (which would be approximately 6 courses or at

least 18 semester credit hours), but rather a track designed to broaden knowledge into related engineering disciplines. Students are encouraged to consider these tracks as a way for them to highlight areas of specialization or interest to employers who benefit from the additional focus within the larger civil or environmental engineering disciplines.

The three initiatives can work together. Since the majors have upper level electives specific to that major, if the courses are cross-listed, it is hoped to increase enrollments in these electives. For example, a cross-listed GIS course was created for civil and environmental engineering students, where in the past if this was just environmental engineering listed, the civil engineering students might not have considered such a course. Similarly, an environmental engineering student will note that the civil engineering surveying course is a worthwhile general engineering elective that can go toward a track in civil engineering while staying in the environmental engineering major.

Newer and/or smaller programs such as the ones at WTAMU have great flexibility in devising and implementing their curriculum. As other universities add civil and/or environmental engineering programs, it is possible to learn how these related but distinct engineering programs can share resources and promote each other to the benefit of the public, as the need for civil and environmental engineers continues to grow at an accelerated pace (11% and 8%, respectively) as noted by the US Bureau of Labor [16,17]. Any means by which to share physical, human, and academic sources across programs is thus both economically more efficient and provides a diversity of program offerings is beneficial for small to mid-sized universities like WTAMU.

References

1. West Texas A&M University, "Quick Facts," http://www.wtamu.edu/about/quick_facts.aspx, [Accessed 21 Feb 2020].
2. HACU, "HACU Member Hispanic Serving Institutions", https://www.hacu.net/assnfe/CompanyDirectory.asp?STYLE=2&COMPANY_TYPE=1,5&SEARCH_TYPE=0#Texas [Accessed 21 Feb 2020].
3. THECB, "Enrollment Forecast 2017-2030 Texas Institutions of Higher Education", http://www.thecb.state.tx.us/reports/PDF/9111.PDF?CFID=92986314&CFTOKEN=94971358 [Accessed 21 Feb 2020].
4. World Population Review, "Amarillo Texas Population 2020", http://worldpopulationreview.com/us-cities/amarillo-population/ [Accessed 21 Feb 2020]
5. ABET, "ABET Accredited Programs", http://main.abet.org/aps/AccreditedProgramsDetails.aspx?OrganizationID=486&ProgramIDs=. [Accessed 04 Feb 2019].
6. World Population Review, "Texas Population 2020", http://worldpopulationreview.com/states/texas-population/ [Accessed 21 Feb 2020]
7. Amarillo College, "Engineering Degree Plan Articulation Agreement," https://www.actx.edu/engineering/article/id/29/page/3, 2014. [Accessed 04 Feb 2019].
8. South Plains College, "Articulation Agreement with WTAMU to Aid in Transferring Engineering, Math Students," South Plains College Plainsman Press, Vol. 55, No. 7, 2013.
9. Lubbock Christian University, "Pre-Engineering," https://lcu.edu/majors-programs/bachelors-degree/math-and-physical-sciences/pre-engineering/. [Accessed 04 Feb 2019].

10. Wayland Baptist University, “Pre-Engineering Program,” https://www.wbu.edu/academics/schools/school-of-math-and-science/programs-and-majors/pre-professional/engineering-pre-professional.htm. [Accessed 04 Feb 2019].
11. WTAMU, “Transfer Plans,” http://www.wtamu.edu/ac-plans.aspx. [Accessed 04 Feb 2019].
12. Texas Common Course Numbering System, https://tccns.org/. [Accessed 04 Feb 2019].
13. ABET, “General Criteria: Student Outcomes,” https://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2018-2019/. [Accessed 04 Feb 2019].
14. US Green Building Council, “LEED is Green Building,” https://new.usgbc.org/leed [Accessed 04 Feb 2019].
15. Leitch, K. and Butler, E., “The Journey to Initial Accreditation of a Civil Engineering Program,” *Proceedings of the 2017 ASEE Annual Conference and Exposition,”* 2017.
16. US Bureau of Labor Statistics, “Occupational Handbook Outlook: Civil Engineers,” http://www.bls.gov/ooh/architecture-and-engineering/civil-engineers.htm. [Accessed 04 Feb 2019].
17. US Bureau of Labor Statistics, “Occupational Handbook Outlook: Environmental Engineers,” https://www.bls.gov/ooh/architecture-and-engineering/environmental-engineers.htm. [Accessed 04 Feb 2019].