7-26-2021

WIP: Halting Attrition in Civil Engineering Programs Through Lower-Division Engagement Course Implementation

Briceland McLaughlin
Boise State University

Nick Hudyma
Boise State University

Robert Hamilton
Boise State University

Bhaskar Chittoori
Boise State University

Mojtaba Sadegh
Boise State University

See next page for additional authors

2021 ASEE ANNUAL CONFERENCE
Virtual Meeting | July 26–29, 2021 | Pacific Daylight Time
Paper ID #33743

WIP: Halting Attrition in Civil Engineering Programs Through Lower-Division Engagement Course Implementation

Ms. Briceland McLaughlin, Boise State University

Briceland McLaughlin is an academic advisor at Boise State University. She graduated with an M.Ed. from the University of Kansas in 2011 and has worked at higher education institutions across the country over the last decade in both student affairs and academic support roles. Briceland is interested in the intersectionality of student development theory and curriculum design.

Dr. Nick Hudyma, Boise State University

Nick is a professor and chair of Civil Engineering at Boise State University. He earned a BSc in Geological Engineering from the University of Manitoba and MS in Civil and Environmental Engineering and PhD in Engineering from the University of Nevada Las Vegas. His research is focused on the laboratory characterization of brittle materials and how their formation and and external factors influence physical and engineering properties.

Dr. Robert Hamilton P.E., Boise State University

Dr. Hamilton has been with Boise State University since 1995, where he helped found the Civil Engineering Department.

Prof. Bhaskar Chittoori P.E., Boise State University

Dr. Bhaskar Chittoori received his bachelor's degree from Jawaharlal Nehru Technological University, Kakinada, India in 2002 and master's degree from National Institute of Technology Karnataka, Surathkal, India in 2004. He received his Ph.D. degree in 2008 from the University of Texas at Arlington. After his Ph.D. he worked at Parsons Brinckerhoff, a well renowned civil engineering design firm, in their Dallas office. Dr. Chittoori joined as Assistant Professor in Geotechnical Engineering area of the Civil Engineering Department of Boise State University in the fall of 2013.; His research interests are clay mineral quantification, sustainability assessment, advanced soil testing and interpretation, soil stabilization, soil reinforcement, pavement materials characterization along with finite element modeling of soil systems. He has published articles in ASCE Geotechnical Journal, ASTM Soil Testing Journal, Transportation Research Board Records, International Conferences on Soil Mechanic Related Topics, ASCE conferences. He is a member of ASCE sustainability committee, TRB Bridges and Foundation's committee. He is a licensed civil engineer in the state of Texas and a member of Chi Epsilon and Tau Beta Pi honor societies.

Dr. Mojtaba Sadegh, Boise State University
Dr. Sondra M Miller P.E., Boise State University

Dr. Sondra M. Miller is an associate professor in the Department of Civil Engineering within the College of Engineering at Boise State University. Miller earned a B.S. in Civil Engineering and a M.S. in Environmental Engineering from the State University of New York at Buffalo, and a Ph.D. in Environmental Engineering from the University of Iowa. Her educational research interests are focused on methods to attract and retain women and underrepresented minorities in STEM fields.

Work in Progress: Halting Attrition in Civil Engineering Programs through Lower-Division Engagement Course Implementation

Introduction and Institutional / Programmatic Background

Retention has been a core issue in science, technology, engineering, and math (STEM) education for decades. Nearly half of students who begin a STEM undergraduate degree do not graduate within 6 years of starting their program [1]. Despite rising numbers of bachelor's degrees being awarded nationally [2], [3], many colleges and universities are seeing lower total enrollments, especially institutions that serve non-traditional student populations.

The civil engineering program at Boise State University, a mid-size institution without a STEM-based, common-core curriculum has seen a significant number of students leave the program over the last five years. A large majority of students who have left the program switched to non-engineering majors. This attrition has usually been seen within the first two to four semesters of coursework and affects traditional and non-traditional students alike. Students who left the civil engineering discipline cited a lack of community and support systems as reasons for leaving. They also suggested a high degree of difficulty in foundational courses (math, chemistry, physics) without an understanding of how the knowledge gained would be practically applied to major-specific coursework in the future.

While major change is no longer a taboo action across higher education, it is an ever-increasing barrier to degree attainment and these barriers increase as time continues before a change is made [4]. Major changes for STEM students, especially at colleges without a common first- and second-year curriculum, place large burdens on students. These burdens come in the form of increased time to graduation, increased use of often finite financial resources, loss of cohort, and student burnout. To avoid these barriers, which disproportionately affect students from underrepresented backgrounds [5], it is critical to help students understand their plans of study and the rigor of these plans, and provide accessible support mechanisms early in the college experience.

In order to begin addressing these barriers to academic success and degree attainment, the CE program at Boise State conducted a review and subsequent remodel of its curriculum. This review included input from faculty, current students, alumni, academic advisors, and their Industry Advisory Board. After these narratives were gathered, the faculty and a member of the advising staff worked to address major negative themes such as a lack of a sense of belonging, early burnout, and early disengagement with a goal of addressing issues through course design instead of relying solely on departmentally-external university support systems.

Curriculum Redesign

The lower division of traditional civil engineering curriculums, and engineering curriculums in general, is largely made up of mathematics, physics, and chemistry coursework. At a majority of universities these courses cannot be modified to engage specific majors due to the nature of "service courses" that are taught by centralized departments outside the purview of engineering programs. These courses tend to be very large and students may have a difficult time finding

peers from their own major. Students need time to develop a connection to peers as well as to the content of their coursework and neither of these goals are easily met in large-format courses that serve all majors [6].

Students desire a community of peers and faculty as well as a sense of belonging [7] within their major. Belonging can be developed in many ways, but a core piece of belonging is knowing what you belong to. When students understand what they are studying, they can connect their input (academic effort) to an output (degree attainment, career) that reflects their values and self-identity now and, in the future, [8]. A large contributing factor to programs not being able to help students make connections is a lack of major-specific courses available where students can find and spend structured time with peers/faculty in their major during the first two years of academic study.

Institutions across the country, including Boise State, have implemented first-year required *Introduction to Engineering* courses. These courses help students understand the rigors of an engineering program, introduce the design process, introduce students to one another, and begin to build a connection to major identity. While these programs provide an abundance of positive outcomes, the civil engineering students taking the courses at Boise State were failing to find community or draw connections with their future study. One student stated, “I was really excited to meet people and form connections, but I was always paired with someone I had nothing in common with from another major. I never saw them again.” Another stated, “It was really hard to draw connections with my major. Everything we were doing had to do with building machines.”

Tinto’s 1975 theory on student departure posits that students are more likely to persist at an institution if they feel a commitment to their institution and desire to obtain a degree, can see progress being made towards their degree, and if they are engaged learners [9]. While Tinto later digs deeper into the social support that is necessary to prevent program/institutional departure [9], [10], Wilcox, et al. showed the extreme importance of social integration in the context of relationships with compatible friends, perception that one’s living situation is acceptable, and social connections that can provide academic support [11]. In order to work towards a student experience that reflects these areas, a new type of 1-credit, non-prerequisite course has been developed. In the new curriculum design, students are required to take three Civil Engineering Engagement Courses (CE-EC or phonetically, “seek”) during their first two years of study. See Appendix A for a sample of course descriptions. These courses aim to incorporate best practices in student development while addressing concerns put forth in an initial curriculum review at the same time. These courses replace the general *Introduction to Engineering* course requirement.

CE-EC courses aim to develop a sense of community amongst civil engineering students, introduce students to faculty in a non-intimidating and humanizing fashion, and allow students to explore the different focus areas of civil engineering early in their academic career. Students outside of civil engineering will also be welcomed into these courses to gain an understanding of the field and learn about potential interdisciplinary collaborations, but a majority of students will be from CE. Courses will also help students become acquainted with the local area and challenges faced by civil engineering professionals. Astin’s 1993 model of IEO provided a useful

framework on which to model a course environment while taking into consideration student inputs and program/student desired outputs [12].

Examples of CE-EC courses include an introduction to geothermal energy in the institution's host city, geohazards in pop-culture, micro-transportation, and hydrology through a rafting trip and time at the Boise Watershed. These courses will be taught in many forms including a traditional 16-week course, 7- or 5-week courses, and even through weekend workshops. Each course will include 15 contact hours. These courses can be taught during multiple parts of the semester and due to this flexibility, the CE-EC courses will be able to help students who need to drop a high-credit bearing course keep their credit hours at a level acceptable to receive federal financial aid through flexible/late registration deadlines into the last third of each semester. There is also a hope that this flexibility will allow faculty to feel less stress about these courses.
In the prior curriculum, students were required to take a general *Introduction to Engineering* course. While this course had many benefits, the CE-EC courses have some overriding benefits including:

- The ability for students to meet more students within their specific major early on in their academic career.
- A focus on major-specific activities instead of the traditional mechanical engineering examples normally relied upon in an introductory engineering course.
- The development of relationships with at least three faculty members in a student's program instead of an instructor outside of their major.
- A light to non-existent workload outside of course meeting times offering more time to focus on foundational courses such as calculus and physics.

Initial CE-EC Course Hurdles

Faculty Hesitancy
There was an initial aversion by faculty to take on a perceived heavier course load, especially in a department with a relatively small number of faculty (1 department chair, 6 tenured faculty, 2 tenure-track faculty, 0 instructors, 1 course-specific adjunct). Faculty range from research intensive (1-1) to teaching intensive (3-3) course loads. In order to ensure equality across the board, teaching loads were adjusted to be based on the number of credits taught and not the number of courses taught. CE-EC courses now fit into teaching loads due to a second curriculum change that affects technical elective design. Technical electives are now broken down where possible into 1-credit courses. This allows flexibility for students to design their own micro-cluster of technical electives and allows faculty the flexibility to teach technical electives during two 5-week sessions and a CE-EC course during the third 5-week session of the semester or vice versa. While CE-EC courses require more resources, particularly when it comes to faculty teaching loads, over time the dividends gained in the form of student retention and success should allow the department to "break even" in terms of additional resources.

It is important to note that faculty were not immediately sold on CE-EC courses after an explanation of how the courses would now be able to fit into their official teaching load. In reality, another course adds a significant workload to faculty each semester, regardless of the number of credits. In the curriculum change process, five faculty members were included on the

Curriculum Design Committee and consistent updates were given at faculty meetings. During faculty meetings, best practices were presented as well as "testimony" from students about their opinion on the possible CE-EC course option alongside the CE-EC idea. Mock syllabi were also put together to showcase how simple a class would be to design and teach as well. Faculty were not all initially on board, but through excessive transparency in course outcome development, a majority of faculty members are now willing to teach CE-EC courses.

Lowering Faculty Teaching Levels

Faculty in the civil engineering program have traditionally not taught courses below the 300 level. There is very little interaction between students and faculty during the first two years of study. Due to this teaching gap, many longstanding civil engineering faculty are struggling to plan courses that are low-level and involve little to no outside of the classroom assignments. In order to begin the process of assisting faculty in course development, the program is working with a non-engineer academic advisor from a student development background as well as students to field potential topics. The faculty have been instructed to create "Discovery Channel" types of short courses. This course metaphor has helped faculty and outside stakeholders understand the difficulty level and workload associated with CE-EC courses. Facullty are alos working with Boise State's *Center for Teaching and Learning* to develop CE-EC syllabi.

Student Course Sequencing

Student course sequencing is always a hurdle. Students enter university under a variety of scenarios. Some are ahead of their peers because of concurrent enrollment, AP courses, CLEP Exams, etc., and others are behind their peers in areas such as their math sequence. Some students also fall behind once they arrive due to failed courses or the need to progress towards graduation at a slower pace in order to succeed. Every student is different and because of this, not all students will be able to enroll in one or all of their required CE-EC courses during their first two years of study without going beyond credit or personal limits.

In order to ensure students are receiving a benefit from CE-EC courses, no matter what point in their academic career they take the courses (it will be highly encouraged to take these courses in the first two years), we will be offering different options that will appeal to different years. First is a Foundations of Engineering (FE) Exam preparation course students will be able to utilize to satisfy one CE-EC credit. This gives extra support on the back end of degree attainment. A special projects course where students work on American Society of Civil Engineering and American Institute of Steel Construction challenge projects (Concrete Canoe / Steel Bridge / Sustainable Solutions) will also be available to satisfy the CE-EC course requirement. Upper-division students will be given the option of which courses they would like to participate in. If they choose traditional CE-EC courses, they will be able to serve in a mentor capacity for the course. We believe this will help to integrate non-traditional students into the community without forcing them to participate as a normal first-year. As students progress in this program, they meet with an advisor semesterly and all CE-EC options will be reviewed so they can make informed decisions.

Discussion and Future Study

CE-EC course development and implementation is currently in progress. A portion of the current student population is currently participating in the special projects CE-EC course. This course has been offered for many years, but participation has been low, between 4-11 participants per semester over the last 5 years. The course has undergone a redesign to meet the goals of a CE-EC course. It now gives students the opportunity to take on leadership roles and participate in competitions put on by the American Society for Civil Engineering (concrete canoe and sustainable solutions) and the American Institute of Steel Construction (steel bridge) as well as introducing students to basic concepts within civil engineering such as turbidity measurements, basic concrete and structural design, and transportation planning. In 2020-2021, first year students were encouraged to participate and informed about the course during fall orientation and course enrollment. The course filled each semester to the enrollment capacity of 50 students. This may be partially due to this CE-EC course being offered in-person during COVID when many classes were being taught online, but the high enrollment is already being seen with for Fall 2021and this is expected to continue with first-year orientation and course enrollment.

Many upperclassmen have decided to take the course to meet faculty, gain leadership skills, and develop relationships with other civil engineering students. Anecdotal evidence based upon student course evaluations suggests that the students are forming relationships and being introduced to civil engineering topics in a way that they enjoy and can connect to career aspirations. Students have stated they feel closer to the degree program because of their ability to interact with faculty in what feels like a more informal course setting. They also appreciate the extra support provided by consistent academic advisor presence during each course meeting.

With only 2 semesters and limited offerings of CE-EC courses, the preliminary data is promising in terms of major changes. In fall of 2020 a total of 29 lower-division students left the major. Before the CE-EC course began, the average loss of lower division students during the fall semester over the last five years (August 1-December 31) was 34.8 students. In the spring of 2021, 17 students left the program. The average number of spring semester withdrawals over the last four years (January 1 to May 3, not including Spring 2021) was 36.25 students.

There are two complicating factors that will need to be accounted for in future study. First is COVID conditions during the first year of CE-EC course offerings. While the student population at this particular university has remained similar to previous years, there is a large possibility that students who are predisposed to risk factors that would cause them to change major are not in the student population. The second complicating factor is the almost simultaneous addition of a dedicated academic advisor for students in the civil engineering major. This shift has brought significant and positive changes to the program as well as to the support and connections provided to students. Advising/support activities that occur outside of CE-EC courses will need to be isolated in future study.

In the future, the research team will continue building on major change quantitative data and use this to track overall student departures as well as delving deeper into why major switches occur during the semester through the distribution of departure surveys. The team will also distribute evaluations at the end of each CE-EC course looking at specific CE-EC course learning

outcomes along with coded narratives. These coded narratives will focus on a sense of belonging, program connection, peer connections, and overall program satisfaction in the first two years of study. Lastly, to draw a true baseline of study, current sophomores and juniors who have gone through the CE program having taken a general *Introduction to Engineering* course, will be surveyed on their overall experiences within the college and major.

Conclusions

The programmatic addition of CE-EC courses to the civil engineering curriculum at Boise State University and the ongoing study of the outcomes of these courses begins to unpack the benefits and challenges of major-specific introductory engineering courses in a non-common core curriculum as well as the impact on major, college, and institutional departure. Future work will look at course goal attainment and compare faculty generated course learning outcomes and student perceived outcomes. It is our hope that a true focus on the academic student experience with regard to retention in the first two years of study will not only lead to lower attrition rates and a rise in general student satisfaction, but also encapsulate specific course features that other programs may utilize in their own retention models.

References

[1] K. Eagan, S. Hurtado, T. Figueroa, & B. Hughes. "Examining STEM pathways among students who begin college at four-year institutions" *Paper Prepared for the Committee on Barriers and Opportunities in Completing 2- and 4- Year STEM Degrees* 2014 (May), 1–27.

[2] M. Gibbons. "Engineering by the Numbers." *American Society for Engineering Education*, 2010. Available at https://www.asee.org/papers-and-publications/publications/college-profiles/10EngineeringbytheNumbersPart1.pdf [Accessed 7 January 2002].

[3] "Engineering and Engineering Technology by the Numbers 2019." *American Society for Engineering Education* Washington, DC. Available at: https://ira.asee.org/wp-content/uploads/2021/02/Engineering-by-the-Numbers-FINAL-2021.pdf [Accessed 7 January 2021].

[4] L. Willcoxson & M. Wynder. "The Relationship between Choice of Major and Career, Experience of University and Attrition," *Australian Journal of Education*. 2010; 54(2):175-189. Available at doi:10.1177/000494411005400205 [Accessed 29 December 2019].

[5] J.P. Bean & B.S. Metzner. A Conceptual Model of Nontraditional Undergraduate Student Attrition. *Review of Educational Research*. 1985;55(4):485-540. doi:10.3102/00346543055004485

[6] M. Hoit & M. Ohland. The impact of a discipline-based introduction to engineering course on improving retention. *Journal of Engineering Education*, 87(1), 79-85, 1998.

[7] R. M. Marra, K. A. Rodgers, D. Shen, & B. Bogue. Leaving engineering: A multi-year single institution study. *Journal of Engineering Education*, 101(1), 6-27, 2012. Available at: HTTPS://doi/abs/10.1002/j.2168-9830.2012.tb00039.x [12 February 2021].

[8] H.M Matusovich, R.A Streveler, & R.L Miller. Why do students choose engineering? A qualitative longitudinal investigation of students' motivational values. *Journal of Engineering Education*, 99(4), 289-303, 2010. Available: https://doi/abs/10.1002/j.21689830.2010.tb01064.x. [Accesses 2 January 2021].

[9] V. Tinto. "Dropout From Higher Education: A Theoretical Synthesis of Recent Research." *Review of Educational Research*, 45, 89-125, 1975.

[10] V. Tinto. *Leaving College: Rethinking the Causes and Cures of Student Attrition*, 2nd(ed.), Chicago: University of Chicago Press, 1993.

[11] P. Wilcox, S.Winn, & M. Fyvie-Gauld. "It was nothing to do with the university, it was just the people": The role of social support in the first-year experience of higher education. *Studies in Higher Education*, 30 (6), 707-722, 2005.

[12] A.W. Astin. What matters in college? Four critical years revisited. San Francisco, CA: Jossey-Bass, 1993.

Appendix A: Sample of Civil Engineering Engagement Courses (CE-EC)

Course	Overview	Faculty Type	Audience
Special Projects	Students participate in low level exploration projects and compete in professional association design/build competitions.	Team of Faculty / Academic Advisor	Freshmen, Sophomores, Juniors, Seniors
Water in Boise: The Boise River and Beyond	A holistic look at local water systems; natural and person-made.	Faculty (Non-Adjunct / Instructor)	Freshmen, Sophomores
Geologic Hazards in Pop Culture: Myth vs. Reality	Overview of geologic hazards in the context of how they affect infrastructure. Film vs. reality.	Faculty (Non-Adjunct / Instructor)	Freshmen, Sophomores
Environmental Restoration After the Idaho Gold Rush	History from the perspective of infrastructure	Faculty (Non-Adjunct / Instructor) Interdisciplinary with Anthropology Faculty	Freshmen, Sophomores
Give a Dam!	Environmental effects of dams on local and national water systems.	Faculty (Non-Adjunct / Instructor)	Freshmen, Sophomores
Green Transportation in Boise	Focus on Green Transportation methods within city limits. Field Trips.	Faculty (Non-Adjunct / Instructor)	Freshmen, Sophomores
FE Exam Prep	Foundations of Engineering Exam preparation	Team of Faculty	Juniors, Seniors