From First-Year Classes to Comprehensive First-Year Experience: 10 Years of Continuous Improvement

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Purpose

The purpose of this paper is to share the development of the first-year experience during the first ten years of an engineering program in a small, rural, teaching-focused liberal arts institution. Major changes to the program and student experience are shared in this paper.

Context

Many small liberal arts institutions have expanded their offerings into STEM majors in order to increase enrollment as students gravitate toward these majors. This is one such institution, a small, rural, liberal arts, religiously-affiliated university that chose to expand its undergraduate programming with a School of Engineering. This was chosen to support the local rural student population and the regional employment needs. The institution is less than an hour from a large public institution known for its engineering, however many local students had been increasingly unable to attend the large local institution for a number of reasons including the preparation available at the rural high schools. There are many local manufacturing and pharmaceutical plants that would benefit from local engineers. To meet these needs, the School of Engineering offers a single degree, a Bachelor of Science in Engineering, with four current concentrations: mechanical, chemical, electrical, and electromechanical engineering. The first class graduated in 2020, with ABET accreditation following in 2022 due to pandemic delays. Engineering students have ranged between 3 – 5% of the total undergraduate population at this institution. As we approach our next ABET review and our ten-year anniversary, the faculty are taking a look back at where we started, where we've come, and where we intend to go during our next ten years.

Methodology

This study is a retrospective case study. In a retrospective case study, a significant event or situation has occurred that is worthy of analysis. Longitudinal data, including first-person accounts and historical data, are collected without premeditation and are used to develop an understanding of the significant event or situation [1].

For this retrospective case study, a relatively new school of engineering is reaching a ten-year milestone. As part of this achievement, the faculty are taking a step back to recognize the evolution of the department in order to support the next decade of development. In case study research, a variety of data sources are used to develop an understanding of a case, a situation or event of interest. These data sources are used to create a detailed description of the case, and can include descriptions of the case from the researchers, interviews of those involved in the case, demographic and other numerical data to describe the case, and content or artifacts related to the case. Further analysis of these data can be done, including thematic or content analysis of qualitative data and statistical analysis of quantitative data to support the overall description of the case [2].

Data included in this study are first-person perspectives of the faculty authors, documents from courses and co-curricular activities, social media and press releases, and general demographic information about students. As part of an overall ten-year retrospective, documents including retreat and meeting minutes were reviewed. Major changes in the program were noted, and those

related to first year programming were flagged as a sub-category of interest. Additional documents were reviewed to better understand these changes. These data are not further analyzed but used to support the narrative description of the changes that have occurred. The authors have been involved in the program for the entire 10 years of the School of Engineering and have provided additional insight where appropriate. To reduce bias, documentation related to each change has been reviewed for confirming and disconfirming evidence and to provide details for the narrative.

Always an Engineer

At this institution, any student who can enter the university can join engineering as a major. This was a mandate from the administration at the beginning of the program and contributed to a number of first-year curriculum design decisions. Students started with precalculus rather than calculus as their first math class, however some students would enter the university with algebra or pre-college algebra as their first math course. These students would need some additional classes to support their education before they joined the foundational engineering courses. Alongside the additional non-engineering classes, ENGR 110, a course based on the Wright State Mathematics for Engineers [3] course was developed to provide a stronger connection between mathematics and engineering and to provide additional instruction in MATLAB that is not found in other School of Engineering offerings. This course provides benefits to students and also ensures that they are consistently engaging in engineering courses.

In the first iteration of the first-year curriculum, all engineering students took a foundational introduction to the university course in their first fall semester. Students who were in pre-college algebra or college algebra also took ENGR 110 in this semester. This course was also offered in the spring for transfer students. In reviewing student performance and connection to the department, it was found that students who started in pre-college algebra did not perform well in ENGR 110 and also did not take any engineering courses their first spring semester. The curriculum was modified so that these students would typically take ENGR 110 in their first spring semester, ensuring a consistent connection to the School of Engineering even while taking additional prerequisite courses. The curriculum has been developed so that students are reminded that they are always an engineer, no matter where they are in their studies.

Living and Learning Community

Living and learning communities have been found to be beneficial at a number of institutions, supporting student belonging and community [4]. This is something that the engineering faculty were interested in, and they jumped at the opportunity to be one of the pilot living and learning communities at the institution. This living and learning community was originally not necessarily limited to engineering students and was called RISE, Residents Interested in Science and Engineering. The first year, a pilot community of students who started with precalculus were selected. As expected, students were better able to work together and came together as a community faster due to living together in the dorms and taking the same course schedule. What was not expected was a strong in-group, out-group dynamic with students not in this community that developed with associated social problems bleeding into classroom friction. At least one student left the School of Engineering citing the problems with the living and learning community as the main factor. The faculty debated disbanding the living and learning community. They determined that the benefits were significant for participating students and reasoned that it would be difficult to have in-group/out-group friction if all students were in the

community. Therefore, the following year the RISE community was expanded to include all engineering students.

Living and learning communities typically have all students taking the same classes together; other models like special interest housing exist for general interests. While the community is still called a living and learning community, it does not meet the strictest definition. All incoming engineering students are placed in the same dorm; athletes and honors students may choose to house in special interest housing for those groups instead and local students are not required to stay on campus. All students take the introductory course together in the fall semester but may have different schedules for all of their other courses. In the first year of the expanded community, faculty were concerned that the students in pre-college algebra or college algebra might find additional friction, rather than community, when living in the same environment as students starting in precalculus or higher. Thankfully, that was not the case, and in fact some students in the lower mathematics tiers felt more connected to the engineering community as a whole as reported to faculty.

The RISE community also offers events for students, typically events aimed at being fun and community-oriented in contrast with other School of Engineering events for professional development and service purposes. Examples include a cardboard canoe competition, a murder-mystery night/group acting event, and family-style dinners with program alumni. RISE events are mostly open and advertised to all engineering students in addition to the first-year students with the goal of promoting cross-cohort connections. Some of the larger events, such as cardboard canoe, have attracted participation by more than 1/3 of all enrolled engineering students, though participation does primarily come from first-year students at most events.

Extracurricular Support

Professional Development & Service Events

The School of Engineering required upon founding that all students in first-year classes must also engage in 25 hours combined of professional development and service work per semester to drive attendance at and engagement with critical activities that could not be offered in-class, such as industry speakers, career workshops, and outreach activities with K-12 students including FIRST Lego League. Other developmental activities such as training on fabrication equipment can also count. To ensure these requirements were taken seriously they were embedded in course grading – essentially counting as homework for ENGR110 along with the first-year design sequence of ENGR120 and ENGR121. This requirement has remained, though some offerings in both categories have changed over time. In the first two years of the program, service opportunities were altered to be more obviously connected to the School of Engineering or engineering work as students did not initially feel that these activities made them feel more like an engineer [5]. There are typically many more events and hours available than students need, so there is a significant element of choice. Overall, this has proven a robust method to drive early engagement with such offerings outside of class time. Having sampled different offerings in their first year of study, many students continue to attend and engage with these events throughout their course of study. Requiring service and professional development also supports engineering identity growth [6].

Computing

The School of Engineering did not have a computer lab available for student use. Instead, for the first three years, requirements and recommendations for student laptops were given to all incoming students so that they could run the software they would be given as part of the program as seen in the summer orientation letter to students, 2018:

> "**All Campbell Engineering majors are REQUIRED to have a laptop computer capable of running the industry-standard engineering software that we will provide you (free of charge!) in the fall.** Your laptop will be used regularly in class and for assignments and is necessary to succeed in the engineering program. ***Student laptops must meet or exceed the minimum specifications (attached to this letter), including having Microsoft Windows 10 installed. Note that School of Engineering specifications differ from and exceed the University's general recommendations."***

Not all students were able or willing to meet these expectations; some were financially unable to purchase compatible equipment, while others wanted to keep their Apple or other device that would not run the expected software. The Makerspace had five computers available if students needed them as well as seven loaner laptops that could be used by students in need, however this was not a reasonable long-term solution.

During the third year, faculty negotiated a laptop fee for incoming engineering students with the institution's administration, which allowed issuing a laptop with a four-year warranty and on-campus repair (when possible) as standard for engineering students. This fee allowed students using grants and scholarships to more easily use their funds on this equipment, standardized equipment across students, allowed for easier installation and upgrades for engineering software on student computers, and reduced the price for a high-quality computer for all students due to volume discounts. The standardization allowed better technical support to ensure all students were able to consistently access the programs needed in classes throughout their degree program.

The loaner laptop program was retained and expanded, using the same laptops issued to students. In the event a student's laptop needs repair or is simply forgotten, they can check out a comparable laptop in the main engineering building for short-term use. Faculty can therefore be quite sure that students have access to adequate computing resources and the standard software.

Spatial Visualization

The first-year faculty are consistently seeking evidence-based ways to support their students. In the third year of the program, Sheryl Sorby's spatial visualization skills (SVS) course was included in the curriculum [7]. Students who tested below 70% on the PSVT:R [8] were expected to attend a 10-week, 15-hour SVS course intended to improve graduation rates. Students would earn 7.5 hours of professional development credit (of the 25 hours required in ENGR 110 and 120). PSVT:R scores improved an average of 41%, with 83% of students improving. Over 75% of the students in ENGR 110 scored lower than 70% on their initial PSVT:R. The following year, the SVS course was integrated into ENGR 110 instead of providing it as a required extracurricular activity to support student growth without requiring additional time.

Tutoring Center

Upon the formation of the School of Engineering, the university had existing structures for academic support including a general tutoring center, based in the library. However, these tutors were not specific to engineering classes, were not prepared for engineering content, were not

easily accessible for engineering students, and were bound by policies that were not compatible with engineering's instructional methods. For example, the university's tutoring center policies required all work to be brought by students on paper rather than digitally, which would be a challenge for CAD or coding work. To support further growth, the first-year engineering faculty worked with the university academic support services to create an engineering-specific tutoring center, staffed by engineering students in the main engineering building during hours that engineering students would be likely to attend. The Engineering Tutoring Center is also available by video call for students living or traveling off-campus. To encourage student engagement with tutors, requirements for mandatory meetings with tutors in the foundational engineering classes were set. Currently, assignments in ENGR100 (the success seminar) and ENGR120 (the first course of the design sequence) task students to locate the Engineering Tutoring Center and to speak with the tutors about course materials, respectively. In addition to content support via the tutors, students are often found working on their assignments in the building during the tutoring hours so that they can seek support if needed. This provides a space, potential classmates to discuss assignments with, and tutoring support for engineering students.

Unexpected Benefits

Transitioning to a comprehensive first-year engineering experience brought benefits beyond what the faculty expected as they enacted these improvements. At a University-level Retention Committee meeting, a panel of second-year students who were transferring to a new institution were asked about their experience. One of the Committee members asked the group about their experiences in the University's introductory course, CUFS100. The panel members who took the common offering did not believe it was beneficial to their first year or beyond experience. However, the panel member who was an engineering major discussed the benefits of ENGR100 to their engineering identity and their preparation for their other courses.

During COVID the university sent all students home in March 2020 and chose to re-open the dorms that fall, offering all rooms as private rooms and waiving the private room fee [9]. Many classes were at least partially virtual as classrooms were typically limited to 50% capacity and students who were exposed were expected to quarantine even if they felt fine [10]. For first-year engineering students, the living and learning community was a lifeline. From the Student Advisory Committee Meeting November 11, 2020 minutes, "Freshmen perceive Campbell Engineering as a welcoming environment. RISE is promoting a sense of community." In a time of isolation, the living and learning community provided a connection for incoming students.

RISE also encouraged students to transfer into engineering. At least two students transferred from other majors, describing the camaraderie and projects they saw in the dorms as reasons for changing their major. One student chose to join engineering before classes began after seeing the support for engineering students during the orientation activities and living and learning community.

Recommendations

Based on our review, there were three improvements we found to be particularly beneficial that may also be of interest to similar institutions.

1. An engineering-specific dorm for all incoming first-year students is beneficial. Community is an important component of support for many engineering students.

Housing incoming residential engineering students in the same dorm has provided benefits beyond the expected, while a more exclusive living and learning community caused more friction than expected.
2. Supporting students through engineering-specific tutoring supports student success.
3. Purchasing student computers as part of an initial fee can greatly streamline IT support and student access. In small programs or programs where space is at a premium, this provides common resources and access. This also streamlines purchasing for students relying on scholarships, grants, or funding sources that pay the institution directly.

Conclusions

The first ten years of the new program saw changes to the curriculum, student support, and the development of a living and learning community. From the outset, the School of Engineering viewed its students as a community of practice, focusing on developing their engineering identity in multiple ways during their first year. The support structures are recognized not only by students within the program but also by other students across campus, some of whom changed their major to be a part of this kind of community. As we look back at the changes that have been made, we share our story so that others who are developing a new program or implementing new student support practices as part of an existing program can share in our journey.

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