Extended Abstract - Analyzing the First Year of a Freshman Engineering Experience Pilot Program

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Abstract – **The North Dakota State University College of Engineering has over 500 freshmen enter the engineering program each fall. Of these students, approximately 34% graduate with an engineering degree within six years. A core group of faculty representing each of the different engineering departments has collaborated on the development of two freshman engineering courses to increase engagement and thereby achieve a higher retention rate for these students. The first course began in the fall of 2013 with 33 students, all of which were undeclared as to their intended engineering field, but calculus-ready. Eleven students enrolled in the second semester course. These courses are designed around project-based learning to engage the students in hands-on interactive experiences. The courses increased in rigor over the two semesters and had a unique design that was influenced by the interest of the students. This gave the students flexibility in the preferred deliverables, and met the requirement for several of the departments' graphical communication courses. These courses also include content for students to substitute or waiver some of their freshman general education requirements. Although mainly implemented to improve retention, several other benefits have been encountered during the pilot program; chiefly, influencing graduate student mentors in regards to teaching careers and improvement in student professional skills. Challenges have also been realized such as how to; 1) structure course substitutions, 2) meeting prerequisites from different engineering departments, 3) determining which classification of students to include given limited resources, 4) structuring the courses without full-time course instructors, and 5) implementing a systemic college change in a traditional instructional system. This paper describes the initial design of the first year engineering program in regards to the benefits and challenges mentioned above. It also describes the preliminary data collected from the faculty and students during the first year's implementation process.**

Index Terms – First Year Engineering Experience, Project-based-learning, engineering retention

INTRODUCTION

Many engineering programs struggle with freshman retention. Reasons for retention, or lack thereof, are complex and many publications exist detailing various efforts [1, 2]. Additionally, there is no shortage of calls for reimagining engineering education [1, 2], but a few items consistently appear as critical needs; 1) creativity, 2) teamwork, and 3) ability to pursue knowledge. At the same time, many universities are placing more emphasis on research success metrics, such as publications, grants, and numbers of graduate students. This emphasis, coupled with limited resources, can result in reduced time spent with undergraduates, especially freshman students, and often results in larger class sizes that can seem impersonal to a new student. This situation is a kind of perfect storm and has been named so by the National Academy of Engineering [1]. It is critical that a sustainable and scalable solution be found to abate the storm.

NDSU's College of Engineering consists of 6 departments; 1) Agriculture and Biosystems Engineering, 2) Civil Engineering, 3) Construction Management and Engineering, 4) Electrical and Computer Engineering, 5) Industrial and Manufacturing Engineering, and 6) Mechanical Engineering. Programs within each department have a few unique courses within the freshman and sophomore years, thus finding common credit for a first year experience challenging. However, a team of faculty with representative from each department gathered to find a solution.

Project-based-learning (PBL) has been around for many years in medical schools and is now gaining wider acceptance in engineering education circles. PBL offers opportunities for students to exhibit their creativity, grow in teamwork, and polish their ability to pursue knowledge. Because of these advantages, the team wanted to have PBL at the core of the experience for the first year of engineering education.

To overcome the challenge of a common course for each program, the pilot program was set up to be an academic year long sequence comprised of two 3-credit courses. These first semester pilot class substituted for existing courses consisting of University 189: "Skills for Academic Success" (1 credit), and Engineering 110:"Introduction to Engineering (1 Credit).

PROGRAM INTENT

A committee of engineering professors from each of the departments in the college was assembled with the initial charge of improving retention of freshman starting in our major programs. The committee decided to design a First Year Experience (FYE) course that would address two areas of concern. The first being an understanding of what engineering is and how it can be applied in society. The second concern of the committee was that students did not see how curriculum components came together to provide the background for preparing the novice engineer for their first employment opportunity. In considering these two objectives, the committee felt that a problem-based learning approach could do a most efficient job in the transition of high school scholars to active-learning engineering students. As a fall semester was quickly approaching, the committee decided that the best source of information about the effectiveness of such a course would be to actually pilot an offering to a limited number of students that would test this stance.

COURSE DESIGN

I. Fall Semester

The first semester pilot course for the First Year Experience course was designed to give students an opportunity to learn about the engineering degrees offered at North Dakota State University, the engineering design process, teamwork, and leadership skills, professional communication skills, and ethics. These learning objectives were achieved through three different student-led projects. These projects highlighted the fields of engineering at North Dakota State University and also allowed the students to see how the different engineering fields worked in unison. These projects included: analysis of a broken spring, bridge construction out of balsa wood and tongue depressors, and creation of a basic electrical circuit that converted light into audible sound. The students were responsible for reporting their projects via technical written reports and oral presentations.

II. Spring Semester

The second semester pilot course for the First Year Experience course was designed to give students an opportunity to learn and practice engineering design, graphical communication, professional communications (oral and written), teamwork skills, and ethics. These outcomes would be achieved through a student-led, project-based learning environment in the context of a large, globally-relevant engineering design problem.

The structure of the course was intended to be independent of the chosen engineering system so it could be replicated by substituting a different complex engineering design problem in the first week. It was loosely modeled after a senior capstone design experience where each team meets with a faculty member one hour per week during the semester to mark progress, answer questions, and be supported in the design process.

On the first day, students were presented with data on the amount of food waste generated from an NDSU dining hall on a typical day. They were also given information on other "waste" sources on campus including livestock manure and vegetation from grounds maintenance. The data was given simply as a situation, not necessarily a problem, and asked if the campus could or should be doing something other than current practice. The situation was presented as an opportunity so that the identified materials might be viewed as resources to be used rather than wastes that needed disposal.

All student teams met course objectives by identifying a technical constraint in the system, designing and carrying out an experiment to test that constraint, demonstrating basic competency in graphical communication using CREO, and presenting effective written and oral reports communicating their findings. Another course goal was for students to identify and articulate an ethical component of their system component but the ethical aspects were discussed more extensively when the larger system was being identified.

DATA

Due to the nature of the course and being the first year this course was offered, the standard university end of course student rating of instruction (SROI) evaluation was not used after the 1st semester. In lieu of the standard evaluation, the director of the student support center in the College of Engineering Dean's office sat down with the students at the conclusion of the semester to collect qualitative data about how the course met the students' expectations. A summary of some of the most relevant responses are shown below.

<u>1st semester (33 students)</u>

- Overall rating of the course = 3.53/5
- Would you take class again? 31 Yes; 1 Maybe; 1 No
- What was most valuable about the course?
  - Were able to see a variety of engineering fields
  - Better hands-on experience than other general education courses
  - Helped make decision about which major to choose
  - Learning the importance 21st century skills, teamwork, oral communication, collaboration, critical thinking, and technical writing
- What was least valuable about the course?
  - Difficult to design solutions around ambiguous outcomes
  - Concern about not getting the same knowledge of the substituted course (graphical communication)

<u>2nd semester (11 students)</u>

- Overall rating of the course = 4.18/5
- Would you take class again? 11 Yes; 0 Maybe; 0 No
- What was most valuable about the course?

  - Learning about technical writing and formal presentations
  - Learning to pay attention to detail
  - Practical experiments and working through real-world problems
  - The smaller class size allowed for valuable collaboration
- What was least valuable about the course?
  - Lack of depth of the graphics component
  - Maybe too much time doing research and not enough time in the application process

OTHER OUTCOMES

I. Upperclassmen as Mentors

During the initial creation of the First Year Experience course the role of upperclassmen (senior level and graduate level students) would be to assist in daily class activities which included grading, answering questions, and assisting the professors. By the end of the fall semester the role of the upper classmen changed drastically. Their roles changed from an assistant of the professors to a mentor for the students in the class. The mentors became responsible for having direct involvement with the class projects and the students. By the spring semester of the pilot course the mentors were responsible for creating daily material and were leading class discussion. This inclusion of the mentors has helped improve the involvement of students because the mentors bring relatable experiences to the classroom.

With the mentors leading the class the professors were able to analyze the classroom and the mentors' performance. This allowed the professors to give the mentors direct feedback and advice on how to improve their teaching skills. This was an unexpected outcome of the class. Not only was the class able to give new engineering students hands on experience, but it allowed upperclassmen insight and basic teaching skills with direct leadership from professors all while using innovative teaching methods.

II. Collaboration between faculty members

One of the more satisfying features of the FYE effort at NDSU has been the dynamic and creative interaction amongst faculty from all departments in the College. The entire team contributed to the concepts and organization for the first pilot offering. In addition, relationships have been built with the university-wide General Education Committee (GenEd). The GenEd Committee has been highly collaborative in identifying procedures for recognizing the pilot courses as fulfilling certain academic requirements and on constructing plans for more robust and lasting positioning of eventual permanent FYE courses within the GenEd environment.

DISCUSSION

A major difference between the fall and spring semester pilot courses was introducing a globally-relevant engineering problem in the spring rather than three small close ended projects that were conducted in the fall. The students showed more investment in working on a problem with global relevancy. This could be attributed to the staff allowing the class to be directly driven by the students in regards to the students deciding on their own deliverables. It could also be attributed to the involvement of the upperclassmen as mentors, as the students of the class highly rated the increased involvement of the upperclassmen.

FUTURE PLANS

These courses will be offered again as a pilot in 2014-15 with permanent course numbers. Two sections will be offered in fall 2014, with an enrollment limit of 28 per section. Course content will be similar to the past semesters, with course outcomes designed around project-based learning. Also, the prerequisites of the course will be adjusted to accommodate a more diverse population of students.

North Dakota is experiencing a shortage in the technological workforce. The State government and leading industrial firms are launching a campaign to attract professional and technical talent to fill thousands of positions in the state. The workforce shortfall exists across all industry sectors, but is most noticeable in advanced technology companies that rely most heavily on new engineering talent. This situation offers a positive environment for developing stronger connectivity between the NDSU College of Engineering and the key technological industries in our region. The FYE Committee leadership is planning to engage several of the leading industrial firms in the region in interaction with engineering freshmen.

CONCLUSION

The first year engineering design team considered this year's pilot course very successful for a variety of reasons. Students involved in either of the two courses indicated, overall, that their experience was positive in regards to being actively engaged in the learning process and helping them to make career decisions. The implementation of the course also provided the design team with much needed data and information about how to continue developing the course and administrative procedures to offer the students a much smoother process for incorporating these courses into their respective curricula.

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