Venturing into Discipline-Specific Activities for Different Sections of the same Introductory Engineering Design Course

Amanda Christine Bordelon, Utah Valley University

Amanda Bordelon, PhD, P.E. joined Utah Valley University's faculty in the new Civil Engineering program in August 2018. She has all of her degrees in Civil and Environmental Engineering emphasized in transportation infrastructure and construction materials at the University of Illinois at Urbana-Illinois BS 2005, MS 2007 and PhD 2011. She was also formerly a faculty member at University of Utah for 7 years teaching civil materials and concrete testing. Her research has been in fiber-reinforced concrete overlay pavement design and has tinkered in specialty concrete materials and evaluating test methods that assess quality of constructed materials. She is currently actively involved in professional societies and committees through the American Concrete Institute National and Intermountain Chapter, Transportation Research Board, and International Society for Concrete Pavements. She enjoys leading hands-on laboratory learning of how construction materials are made and helping the new civil engineering students learn the tools to design roadway infrastructure.

Dr. Susan L Thackeray , Utah Valley University

Dr. Susan L. Thackeray is tenured-track faculty in the College of Engineering and Technology at Utah Valley University. She is recognized through multiple awards for her research in science, technology, engineering, and math (STEM). Susan holds a fellowship with Stanford University and a doctorate from Northeastern University, Boston.

Dr. Sean S Tolman, Utah Valley University

Sean S. Tolman is an Associate Professor in the Mechanical Engineering Program at Utah Valley University in Orem, UT. He earned his BSME degree at Brigham Young University in 2002 and a MSME degree from the University of Utah in 2008 before returning to BYU to pursue doctoral studies completing a PhD in 2014. He spent 8 years working in the automotive safety industry specializing in forensic accident reconstruction before becoming a professor. He teaches courses in engineering design and solid mechanics.

Prof. Jane M. Loftus, Utah Valley University

Jane Loftus is an Associate Professor in the Department of Developmental Mathematics and an Affiliated Faculty member for the Department of Engineering at Utah Valley University, Orem, Utah. She received her B.S. in Applied Mathematics from the University of Paisley, Scotland. She then moved to Utah where she received her M.S. in Mathematics and her Ph.D. (ABD) in Electrical Engineering from Brigham Young University, Provo Utah. In addition to working in industry in product development Jane is involved in ongoing research of image reconstruction and is currently working on research in the field of fMRI imaging in conjunction with Dr. Neal Bangerter at Imperial College, London, UK. Jane recently became a Fellow of the HEA and is a strong advocate for experiential and engaged learning.

Venturing into Discipline-Specific Activities for Different Sections of the Same Introductory Engineering Design Course

Authors

Amanda C. Bordelon, Civil Engineering Program, Utah Valley University

Susan L. Thackeray, Technology Management Department, Utah Valley University

Sean S. Tolman, Mechanical Engineering Program, Utah Valley University

Jane M. Loftus, Developmental Mathematics Department, Utah Valley University

Abstract

This complete evidence-based practice paper will describe two approaches implemented of a design-based introduction to engineering course: a discipline-specific and a generalized mechanical engineering approach. The Introduction to Engineering course is a three hour per week hands-on design class with the goal of providing students with the feeling of what engineering is like through engaging activities related to engineering and developing skills like teamwork, communication, and following a design process. With the intention that the class should excite, prepare, and retain more students, there has been conflicting agreement on if it should be delivered as a discipline-specific or as a universal cross-disciplinary version.

For this study, students were assessed with Likert-based survey questions about how they felt the class prepared them or engaged them for a career in engineering and if they planned to remain in their program. The survey was given at the end of the semester they took their respective Introduction to Engineering course. Statistical p-values were calculated from the Likert scores with respect to the discipline area of the student, the instructor, the semester, and the demographics of the student class population. The course was delivered in one semester as a generalized mechanical-engineering focused design approach and then in a second semester as the three discipline-specific (civil, electrical, and mechanical) approaches. The course was co-taught by three instructors (from civil, electrical, and mechanical), and for the generalized mechanical approach all three instructors gave the same lectures, assignments, and in-class activities. In both semesters, the core of the course involved having students complete a group design process and individual written reports. In the generalized mechanical approach, students also have lectures and assignments related to learning Excel, SolidWorks, hands-on machine tools, and electrical wiring scenarios using Arduinos. In the civil-specific approach, for example, the students learned AutoCAD instead of SolidWorks, and performed activities and assignments such as building a truss, testing water quality, performing a traffic study, and attending a public planning commission meeting instead of using Arduinos. The students were often registered for the version that matched their schedule rather than based on the version that matched their discipline of interest, so all three sections in both semesters had a distribution of the student's preferred programs.

The survey results after 1 semester of each delivery method (114 students completing the survey from both semesters) did not show any statistical difference between the discipline-specific and the generalized version of the course. The survey regardless of which approach was delivered did verify that 65% of the students felt it was engaging, 72% said it increased their interest in a career in engineering, and 84% stated they plan to continue in their respective program. The plan is to continue with the discipline-

specific versions of the course for at least another semester to gather additional statistical data. The survey is also intended to be sent out to the same students in their junior year to re-evaluate how they felt the introductory course engaged and prepared them for their remaining courses.

Keywords

multidisciplinary design, first year, civil engineering, mechanical engineering, electrical engineering

Introduction

For most Universities, a recent push is to implement discipline-specific and hands-on experiences, rather than seminars for the "Introduction to Engineering" courses. The process of designing and problem-solving is one that is shared among all engineering fields. However each discipline has its own physical or software tools, or necessary skills they will use to perform this design and problem solving. The scale of projects is also highly variable, from small gadgets in mechanical or computer engineering to large dams or global internet networks in civil and electrical engineering. The goal for our university with the "Introduction to Engineering" course was firstly to engage students and secondly to retain students in engineering. This course has gone through iterations of small hands-on activities or projects, to a full-semester long design process for students in groups. Most of the projects and activities tended to have a mechanical engineering focus either due to the higher number of students in mechanical engineering, the instructor being a mechanical engineer, with the in-class activities and skills training being centered on the mechanical engineering field.

A review of past literature reveals that there is still a need for new strategies which intertwine multi-disciplinary concepts, sometimes beyond science and into art and human-aspect design, to solve complex engineering problems [1], [2]. Student retention is a known challenge for first- and second-year engineering programs. Students can become intimidated by the curricula and transfer out of the program or potentially drop out of college. A few studies found that students were more likely to graduate or have higher GPAs in engineering if they have higher self-efficacy or confidence going into or during their introductory course experience [3]–[5]. Students drop out of engineering programs if their expectations of practical or interesting content is not met [6]). Having engaging activities and experienced teachers are found to be helpful in creating the positive environment for the students [7].

In terms of implementation, one study asserted that a first-year engineering course should integrate a mix of disciplines to help students engage with the subject matter and each other to promote a practical approach to problem solving [8]. Their research suggests that students need to prepare for collaborative problem solving to meet the needs of business and industry. Odeh et al. offered three design problems during the semester and students were allowed to pick which problem to execute, each exposing them to different fields of engineering. The review by Dyer [2] echoes the suggestion for an introductory course to be multi-disciplinary.

Around the same time, another study demonstrated that traditional gadget-based course projects were not sufficient nor representative of civil engineering discipline in particular [9]. Dittenber [9] implemented a civil-specific design project in the introduction course for three consecutive semesters (52 students completed the course in this total time). The project including designing and constructing a full-scale bridge and doing a cost-analysis of the materials and construction. He found that the number of students retained in the civil program to the next semester did not change (77%), but the number of students who chose civil after this course retained past their junior year and to graduation at 100% rate of retention. The rate of retention for graduates in civil engineering for the same general introduction course prior to civil-specific project was 79% (based on 81 students).

Venturing into Discipline-Specific Activities for Different Sections of the Same Introductory Engineering Design Course

The purpose of this research study is to implement and compare retentions for an "Introduction to Engineering" course that has a mechanical engineering focused design process to the same course but offered in three discipline-specific sections (mechanical, electrical, and civil engineering). Each discipline-specific section attempted to implement software, tools, activities, and have an instructor who provides examples in that specific discipline area of engineering [7]. A list of the activities or changes are described in Table 1 for each discipline-specific version.

The purpose of these changes is to still have all students learn the process to design and problem solve so they are prepared for all engineering disciplines, but at the same time give them a little hands-on teaser of what a specific discipline might entail [10]. This approach is constructed with basic assumptions that a student arrives with prior acknowledgement of desiring a degree in engineering and has begun to embrace courses towards their discipline area. In this situation, students are expected to focus less on determining what the different engineering disciplines are and instead focus more on experiencing what engineering is like [11].Since this course is generally only taken by students already in engineering, the purpose of encouraging a conceptual design experience is to retain more students in their respective discipline fields, or at least within engineering.

Table 1. Examples of Activities Specific to Each Discipline-Version

Mechanical Engineering	Civil Engineering	Electrical Engineering
Excel and SolidWorks	Excel and AutoCAD	Matlab and Labview
Prototype required	Souvenir required	Prototype required
Machine shop tool training	Machine shop tool training	Soldering
Arduino wiring	Truss design and force balance	Arduino wiring
	Concrete materials testing	Fritzing
	Pedestrian traffic observation	Digilent and WaveForms
	Public meeting attendance	Robot puppy design

Methodology

At Utah Valley University, a new department was created in 2018 encompassing new Bachelor's (four-year) programs in each of four areas: Civil Engineering, Computer Engineering, Electrical Engineering and Mechanical Engineering. Prior to these new programs, the University offered an Associates (two-year) Degree in Pre-Engineering. At the time of its start, all programs used the same introductory design course as a requirement for their incoming freshmen classes. The overall goal of this course is to engage all of the students in engineering by providing an experience related to their career of interest early on in their college education while they are completing other pre-requisite non-engineering courses. This introductory course was focused on Mechanical Engineering Design examples and activities such that the students were encouraged to do their own group semester design projects in a related mechanical topic. Additional mechanical-focused objectives included exposure to software such as SolidWorks, coding and wiring with Arduinos, and experience using machine-tools so they can manufacture their own prototype of their "invented" design concept. This general Mechanical Engineering version of the course was given during the Fall 2018 semester for three sections, each taught by different instructors of three disciplines (Civil, Electrical and Mechanical Engineering) with each instructor following the same lecture content, assignments, and activities during the semester.

Some faculty felt it might be more beneficial to students if they did a discipline-specific introductory course, so it was determined that the department wanted to try offering discipline-specific sections of this

course in the second semester. In fact, the Computer and Electrical Engineering began the process to have their own separate introductory class as a required course. In the meantime, the Civil and Mechanical Engineering areas which are similar enough decided to offer sections of the same course with different activities and different examples of design related to their own discipline area. Students in any of the four programs were still required to take the "Introductory to Engineering" course, and were informed by the first day of class which discipline-specific section they were enrolled in. Still, it seemed students sometimes (due to room or time scheduling) enrolled in a section that was of a different discipline that the one they were pursuing.

For the second semester offering of this Introduction to Engineering course, there were three sections of this course each intended to be specific to the corresponding disciplines (Civil, Electrical, and Mechanical Engineering). A survey was administered at the end of both the Fall 2018 (general mechanical version) and end of the Spring 2019 (discipline-specific version) semesters, to all 3 sections of students in each semester. The intention is to administer the same survey to the same students after they have entered their junior year courses (Spring 2020 and Fall 2020) in order to gage the impact that the course changes on their retention within their discipline-specific program or within engineering.

Course Structure

The Introduction to Engineering course for the Fall 2018 semester consisted of a three hours per week contact time, split either over 2 or 3 lecture sessions per week. Due to high enrollment of 102 students, this course was offered with three sections (30-40 students per section), each taught by different instructors but with the same content and schedule. The main purpose of the Introduction to Engineering course was to explain the engineering design process, which was done through several lectures throughout the semester. Examples of the lecture topics included: explaining the process steps of defining a problem, generating and selecting a solution, modeling, testing, and refinement; describing teamwork and conflict resolution management; and reviewing communication requirements via writing, drawings, posters, and oral presentations. The course also included several specific activities or software related to the discipline of Mechanical Engineering, see Table 1.The objectives of the course were listed in the University curriculum as follows:

- Apply the engineering design process.
- Employ principles of effective teamwork.
- Communicate effectively through written reports and oral presentations.
- Use Computer Aided Design (CAD) software to create basic engineering models and/or drawings.
- Apply modern software tools for engineering analysis and programming.
- Fabricate prototypes safely using power and hand tools.

The percent of class time spent on each objective for each version of the course can be seen in Table 2.

Table 2. Percent of Classroom Time on Course Activities Related to Objectives

Course Activities	Mechanical-Specific Fall 2018 (3 sections) and Spring 2019 (1 section) [138 students in total]	Civil-Specific Spring 2019 (1 section) [30 students enrolled]	Electrical-Specific Spring 2019 (1 section) [10 students enrolled]
Lectures by Instructor on Design Process	24%	21%	22%
Group Worktime	19%	28%	15%
Presenting as Group or with Poster	4%	3%	3%
Software Worktime [Breakdown of Software Learned]	24% [7% EXCEL 17% SolidWorks]	22% [10% EXCEL 12% AutoCAD]	39% [1% EXCEL 17% Matlab 14% LabView 7% WaveForms]
Lab Safety/Fabrication	10%	13%	4%
Other Activities (not related to objectives)	19% Arduino	13% Civil Engineering Demonstrations	8% Arduino/Fritzing

For the second semester of this course in Spring 2019, three sections were offered, each intended with a discipline-specific emphasis (Civil Engineering, Mechanical Engineering, and Electrical Engineering). The course objectives for all Introduction to Engineering sections and all semesters will be kept the same for consistency, articulation, and accreditation. The Civil Engineering Program specific section of the Introduction to Engineering course switched out the Arduino activities and SolidWorks software with civil engineering demonstration activities and AutoCAD software. The Electrical Engineering version replaced Solidworks with LabView, Fritzing, Matlab, and Digilent WaveForms. As mentioned in Table 1, the Civil version also added assignments, particularly one on cost analysis, a required observation visit to a public (city hall or similar) planning meeting, and added lectures on human factor design, student professional groups available, and the licensure process. The Civil Engineering version also switched out the "prototyping" of the actual design solution with a generic "souvenir" of anything they wanted to keep. The Electrical Engineering version did more YouTube videos related to lecture topics, swapped out the machine shop training with coding, wiring and soldering, and then focused only in the last month on the group project prototyping. A summary to compare the course before and after this change is shown in Table 2.

Survey

A retention and engagement survey was administered by the instructors of all the Introduction to Engineering sections during the last two weeks of each semester, before the final exam period. The survey is based on a retention Likert-based questions used at the University of Wisconsin-Madison [12], [13], intended to similarly compare an introductory engineering course that was multidisciplinary versus a disciplinary-specific version. The survey for this study was written in Qualtrics and included the following:

- 2 initial screening questions to help identify which semester and instructor they had
- All participants were asked a retention question of "After taking this course, are you planning to continue in this program?" with the choices "Yes" or "No". Those who chose "No" were asked an additional follow-up multiple answer question of "I changed (or plan to change) my major from my engineering discipline/program to another major because…"

    - I became more interested in another major
    - I did not think I would like performing the type of work associated with this engineering discipline
    - I did not meet minimum academic requirements of my engineering major
    - I did not like the faculty in the Department of Engineering or University
    - I did not like the other students in the Department of Engineering or University
    - I did not feel like I belonged in engineering or in this engineering discipline
    - I had to leave the program for personal, medical, and/or financial reasons
- All participants were asked 10 Likert engagement questions based on a past survey [13]; these questions were "My 'Introduction to Engineering' course…"
    - increased my interest in a career in engineering
    - engaged and/or excited me about my discipline area of engineering
    - made me more likely to complete an undergraduate degree in engineering
    - influenced my educational decisions (course selection and/or student group involvement)
    - taught me valuable technical concepts and skills that I need for engineering courses or an engineering career
    - provided me with the good connections to engineering faculty members
    - taught me about how to contribute to and work well won a diverse engineering team
    - taught me how basic math and science (calculus, chemistry, physics) concepts are applied in engineering projects in my discipline area
    - helped me feel welcome in the Department of Engineering and/or the program
    - helped me obtain internships, co-ops, or a job in an engineering field
- All participants were asked 7 demographic questions (gender, race, first-generation student, financial aid status, year in program, citizenship, self-reported GPA)

There were also comment boxes available related to their perception of the course and their explanation for changing majors. With each semester, one instructor coordinated with the other instructors of that semester to initially post the survey to the students, then the data received after each semester was analyzed, and then held a review meeting to discuss the tabulated results for each semester with the instructors.

For the analysis of the data, the engagement questions (e.g., my introduction to engineering course increase my interest in a career in engineering) responses were converted from a Likert response to a numerical response (e.g., strongly agree = 5). Results were sorted by different categories: section, program pursuing, gender, first-year students, race, financial aid, and citizenship status. Within each sorting, the average responses and a statistical t-test's p-value were recorded.

Results

The Introduction to Engineering course had a total of 178 students enrolled in the combined Fall 2018 and Spring 2019 semesters. Roughly 70% of the students enrolled viewed the survey and 64% (114 students) of the students enrolled accepted to participate in the survey. From those who participated in the surveys, most of the students 52% said they were pursuing the Mechanical Engineering program, followed by 17% pursuing Civil Engineering, 14% pursuing Electrical Engineering, and 12% in Pre-Engineering (intending to possibly go to another University after their sophomore year).

Related to the retention in the program response, overall 84% of those who participated in the survey stated that they are planning to continue in their respective program after taking this course. That leaves 16% (13 students in the Fall 2018 and 5 in Spring 2019) who stated they were not planning to stay in their program. Of those who stated they were not continuing, 11% indicated "I became more interested in

another major", 4% indicated "I did not think I would like performing the type of work associated with this engineering discipline", and 1% indicated "I had to leave the program for personal, medical, and/or financial reasons".

The average Likert scores based on discipline-specific version are shown in Figure 1. There were no noticeable changes in percent of Likert scores for the engagement question results between semesters. In general, the majority of students agreed or strongly agreed to most of the Likert questions (e.g., 65% selected "My Introduction to Engineering course engaged and/or excited me about my discipline area of engineering"). The only exception was most of the students selected disagree or strongly disagree to "helped me obtain internships, co-ops, or a job in an engineering field", but this was not a learning objective of the course.

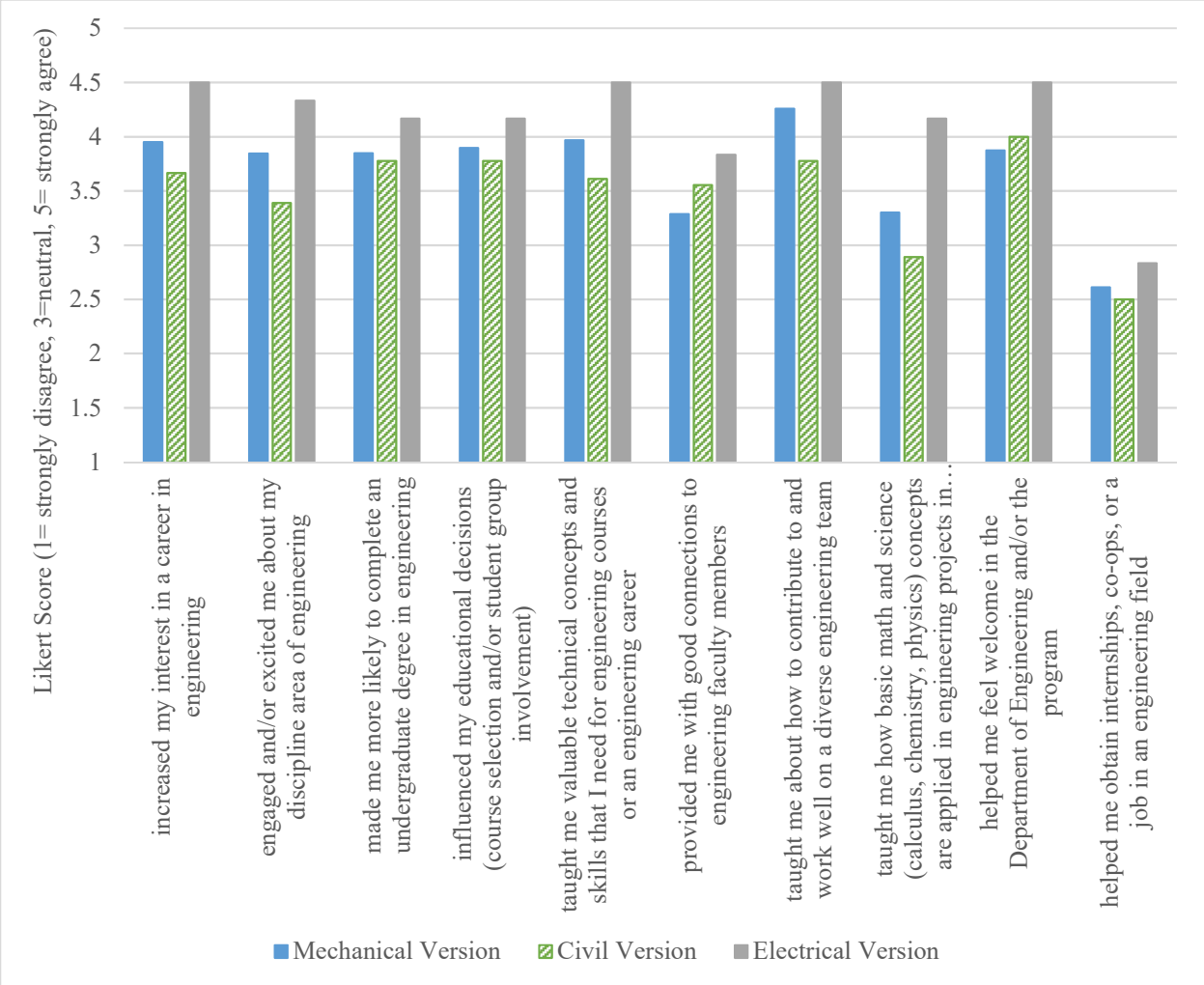

Figure 1. Average survey responses split by discipline-specific versions of the course. The Mechanical version includes the before change (with all three instructors) and the after change with one instructor. The enrollments for these were 138 students took Mechanical version, 30 students took the Civil version, and 10 students took the Electrical version.

Instructor Effect

Two instructors (the Mechanical and Civil program faculty) were the same for both semesters. In fact, the Mechanical faculty instructor has been teaching this course the same way for several years so data from that instructor was looked at in particular since their version is anticipated to have the most consistent average responses from one semester to the next. The Electrical faculty member changed, with the discipline-specific Electrical version taught by an adjunct faculty.

The electrical engineering section in Spring 2019 had the highest Likert scores overall and in the categories of "taught basic math and science for their discipline" (p-value <0.039) and "helped feel welcome in the department" (p-value <0.132), but also had only 6 students who completed the survey. A closer look at the six students in this electrical version shows that they proclaimed to be 3 in electrical engineering, 1 computer engineering, 1 mechanical engineering, and 1 pre-engineering. It is still unknown whether the students liked their discipline-specific version better or if this is just too small of a sample set.

Discipline Effect

The only statistically significant difference (p-value of 0.034) found with offering a civil-specific version versus a general mechanical version was that mechanical students enrolled in the civil-specific section gave a lower score of 2.2 on average for "taught basic math and science for their discipline area" while the civil engineering students gave a score of 3.5 on average for the same question. Since 52% of the students claimed to be mechanical engineering majors, it was discussed that maybe having a mechanical version course may still be preferential in order to reach most students in future semesters.

Demographic Effects

Although this class was intended to be for freshmen, it had 36% sophomores, 11% juniors and 1% seniors taking it. The survey also revealed that 20% were first-generation students which is similar to the rate at the University. Statistically, the survey revealed that the first generation students felt the class made them "more likely to complete their degree". The students' whom had parents paying for college felt that they were more "engaged and excited about their discipline" and "taught them concepts and skills for their career". There was no statistical difference seen based on race/ethnicity (92% were white). The female students (13% of those who took the survey) statistically felt the class provided more "influence on educational decisions" than the male students.

Discussion and Recommendations

The current results do not have a strong indication on whether the discipline-specific course made a difference. The authors intend to deliver the course at least once more as these discipline-specific sections, ideally also notifying students in advance of which section they are enrolling in. A future research opportunity is to offer the course in a later semester where at least one activity from each discipline area would be given by each instructor regardless of the field of expertise of that instructor, so that the students could be exposed briefly to the three main areas. These different offering versions (with discipline specific activities only in a section or with activities of the three disciplines in each section) would help provide more insight into whether the students may change or appreciate their own chosen engineering program.

The authors also intend to administer the same "Engagement Survey" after two years have passed for the same students who completed the Introduction to Engineering course. It will be sent via a link to the students based on their university ID number and should provide additional insight into whether the

course affected the students' retention in their respective program or even in engineering. Based on the number of participants and those who selected they were intending to remain in the program, it is expected that the number of participants in the follow up survey in Spring 2020 and Fall 2020 may be up to 55 students and 41 students, respectively (that is 54% of the original enrollment).

Conclusions

The majority of the students had positive feedback about the course in general. 84% stated they plan to continue in the program. 72% said it increased their interest in a career in engineering. 87% stated it taught them about how to contribute to and work well on a diverse engineering team. 65% stated the course engaged and/or excited them about their discipline area of engineering.

From the two semesters of data, one with the course offered as a mechanical focus, and one with discipline-specific activities, there does not appear to be enough evidence or difference to indicate that the students perceive engineering any differently. Based on t-tests from the Likert survey results, statistically the course with only 10 enrolled students which focused on a specific discipline of electrical engineering had the highest engagement and positive responses. There was also a significantly lower response from the mechanical engineering students who enrolled in the civil-specific section that claimed the civil-version "did not teach as much basic math and science for their discipline area".

The instructors plan to teach at least one more semester with the discipline-specific version to gather more data on the student engagement responses. Two years after each version were given, the instructors intend administer the same survey to the same students in order to determine if the students in reflection felt their version of the introduction course was helpful for them to progress in their respective program choice.

Acknowledgements

The author would like to acknowledge the Utah Valley University's Office of Engaged Learning for funding the project.

References

[1] R. Adams *et al.*, "Multiple Perspectives on Engaging Future Engineers," *J. Eng. Educ.*, vol. 100, no. 1, pp. 48–88, 2011.

[2] M. Dyer, "STEAM without hot air: strategy for educating creative engineers," *Australas. J. Eng. Educ.*, vol. 24, no. 2, pp. 74–85, Jul. 2019.

[3] L. M. Larson, K. M. Pesch, S. Surapaneni, V. S. Bonitz, T.-F. Wu, and J. D. Werbel, "Predicting Graduation: The Role of Mathematics/Science Self-Efficacy," *J. Career Assess.*, vol. 23, no. 3, pp. 399–409, Aug. 2014.

[4] C. Carlson, G. Peterson, and D. Day, "Utilizing Portable Learning Technologies to Improve Student Engagement and Retention," *IEEE Trans. Educ.*, vol. 63, no. 1, pp. 32–38, 2020.

[5] S. B. Robbins, K. Lauver, H. Le, D. Davis, R. Langley, and A. Carlstrom, "Do Psychosocial and Study Skill Factors Predict College Outcomes? A Meta-Analysis.," *Psychological Bulletin*, vol. 130, no. 2. American Psychological Association, Robbins, Steven B.: ACT, Inc., Iowa City, IA, US, 52243-0168, steve.robbins@act.org, pp. 261–288, 2004.

[6] L. Van den Broeck, T. De Laet, M. Lacante, M. Pinxten, C. Van Soom, and G. Langie, "Comparison between bridging students and traditional first-year students in engineering technology," *Eur. J. Eng. Educ.*, vol. 43, no. 5, pp. 741–756, Sep. 2018.

[7] T. Alves, "From food to simulation with Legos: Engaging students in hands-on learning," *Transform. Teach. A Collect. Stories Eng. Fac. Pedagog. Journeys. Synth. Lect. Eng.*, vol. 6, pp. 53–58, 2019.

[8] S. Odeh, S. McKenna, and H. Abu-Mulaweh, "A unified first-year engineering design-based learning course," *Int. J. Mech. Eng. Educ.*, vol. 45, no. 1, pp. 47–58, Oct. 2016.

[9] D. B. Dittenber, "Project based learning in an introduction to civil engineering course: A cascade effect on student engagement and retention in subsequent years," *ASEE Annu. Conf. Expo. Conf. Proc.*, vol. 2017-June, no. Paper 19087, 2017.

[10] C. Pierce, "Creating a community of collaborators to achieve curriculum change," *Transform. Teach. A Collect. Stories Eng. Fac. Pedagog. Journeys. Synth. Lect. Eng.*, vol. 6, pp. 53–58, 2019.

[11] C. S. Kalman, *Successful Science and Engineering Teaching*, vol. 16. Cham: Springer International Publishing, 2018.

[12] T. J. Puccinelli and C. Winsor, "Development and implementation of a new hands-on freshman engineering design course that promotes inclusiveness and retention (work in progress)," *ASEE Annu. Conf. Expo. Conf. Proc.*, vol. 2017-June, 2017.

[13] T. J. Puccinelli, M. E. Fitzpatrick, and G. P. Masters, "The evolution of the freshman engineering experience to increase active learning, retention, and diversity - Work in progress," *ASEE Annu. Conf. Expo. Conf. Proc.*, vol. 2016-June, 2016.