Paper ID #14619

Evaluating the Impact of a Revised Introductory Engineering Course: Student Retention and Success as an Indicator

Dr. Ryan W. Krauss, Southern Illinois University - Edwardsville

Dr. Krauss received his Ph.D. in mechanical engineering from Georgia Tech in 2006. His research interests include modeling and control design for flexible robots, feedback control, and microcontroller-based implementation of feedback control systems. In addition to the freshmen introduction to engineering design course, he has taught courses in mechatronics, controls, vibrations, dynamics and robotics as well as senior design.

Dr. Ryan Fries, Southern Illinois University - Edwardsville

Ryan Fries is an Associate Professor in the Department of Civil Engineering at Southern Illinois University Edwardsville. He earned his BS in Civil Engineering from the University of Delaware and his MS and PhD from Clemson University in South Carolina, where he is a licensed Professional Engineer.

Dr. Cem Karacal, Southern Illinois University - Edwardsville

Dr. Cem Karacal is a Professor of Industrial Engineering and Dean of the School of Engineering at Southern Illinois University Edwardsville. He obtained his Ph.D. and M.S. degrees from Oklahoma State University in 1991 and 1986, respectively. His received his B.Sc. degree from Middle East Technical University, Ankara, Turkey in 1982. He has experience in industry and academia. His main research and teaching interest areas are simulation modeling, quality control, operations research, and facilities layout. Before joining to SIUE he worked at Rochester Institute of Technology as a faculty member and Computer Integrated Manufacturing System project coordinator for RIT's integrated circuit factory. He is a senior member of IIE and SME, and a member of ASEE, Alpha Pi Mu and Tau Beta Pi.

Evaluating the Impact of a Revised Introductory Engineering Course: Student Retention and Success as an Indicator

Abstract

This work in progress describes changes that have been made to a freshmen introduction to engineering course, Engineering Problem Solving (EPS), and investigates whether or not those changes have positively impacted student retention in engineering. The changes include team teaching by instructors with strong teaching records, smaller class sizes, and an emphasis on analysis driven design. Cohorts of students who enrolled in the new and old versions of EPS were compared to one another and two seemingly contradictory trends were observed: students who enrolled in the new version of EPS were more likely to persist in engineering while the fraction of students passing the new version of EPS is lower than the fraction passing the old version. Combining these two observations lead to a statistically significant result: students who earn grades of C or higher in the new version of EPS are more likely to persist in engineering than students earning grades of C or higher in the old version of EPS. The focus on analysis driven design has made the course more rigorous and made it more comparable to upper division engineering courses. As such, the course has become a better indicator of persistence in the engineering curriculum.

Introduction

As part of our NSF STEP project, a new and improved version of our Freshmen Engineering Course has been developed. This paper will provide information on the new format and content of the course as well as share the results in terms of student success and retention rates.

In the past, declared engineering freshmen and students with interest in engineering took the IE 106 - Engineering Problem Solving course (EPS). The course covered basic critical thinking skills and the fundamental steps of problem definition, formulation, and solution techniques common to all engineering disciplines. Case studies and small projects gave students a feel for, and an appreciation of, the different engineering disciplines. Formerly, the course was primarily taught by an adjunct faculty member who had both teaching and industrial experience. Our experience has shown that the student population in the class was rather mixed in terms of preparation level. About half of the students were highly motivated, with clearly defined goals and objectives. The other half of the students were somewhat less motivated, and came with less than adequate science and math background. This student diversity made it a major challenge to design the course content in a way that can be attractive to both populations. In addition, section sizes were very large (80-90 students in each) and the instructor's interaction with students was limited. As a result, mentoring and active learning opportunities were less than ideal.

A large body of literature exists on the freshman experience. Based on existing research and our previous experiences with the course, plans were made to adopt the team teaching model successfully implemented at Virginia Polytechnic Institute and State University. Instead of using adjunct faculty to teach the course, a team of faculty representing each department took the responsibility of developing and teaching different segments of the course content along with a complementary small project on each segment. This format also helps students connect with faculty from different engineering disciplines during their first year. Before the first year of the proposed change, faculty members with demonstrated teaching skills from different engineering fields were provided with summer support to redesign the EPS course as a project-oriented interdisciplinary course.

At Southern Illinois University Edwardsville (SIUE), new freshmen seminar (NFS) is a required course for all incoming first year students. The seminar component is infused into a set of selected general education and discipline specific courses and helps students learn about campus resources and culture. These courses are offered in smaller sections of up to 30 students in each to provide meaningful interactions with the instructors. In its new form, EPS is offered in four sections as a new freshmen seminar course both in fall and spring semesters. The NFS sections are intended for declared engineering majors. The four faculty members teach 4-week long project-based modules focused on their field of study such as Mechanical, Electrical, Civil or Industrial Engineering. The modules are rotated through the sections by instructors switching sections every four weeks.

In addition to the four freshmen seminar sections, a non-freshmen seminar section of the course is offered which is intended for students who are interested in engineering, but have not yet declared engineering majors. This section allows larger enrollment numbers and is primarily offered to recognize the different preparedness, motivation, and commitment levels of the two student populations mentioned above.

A diverse group of graduate assistants with good academic records and communications skills are used to help students with their projects. The course is intended to help improve student understanding of fundamental engineering concepts, the design process, and different disciplines.

Literature Review

Freshman engineering courses vary substantially between universities. A review of previous studies suggests emphasis areas include increasing retention and student success, improving students' concept of what engineers do, and teaching students how to conduct the engineering design process.

Retention and success of engineering students is a notably complex topic and has been extensively examined[1]. Studies agree that graduation and retention have strong links with high school GPA, math SAT scores[2], ACT scores[3], and attitudes about science, math, and computers[4]. Aside from preparedness and financial factors, psychological[5] and personality[6] factors might also influence student persistence in engineering. Others have found that self-confidence was strongly linked to retention[7,8]. Overall, many of these factors that link to the persistence of students in engineering tie to student emotions[9].

Some have suggested that strategies to improve retention in the first year include hands-on engineering projects[10,11] and real-world experience[12]. Participation in co-ops increases self-efficacy which is reported to improve retention; albeit co-op experiences do not usually occur until after the first year[8].

Other researchers argue that student's pathways through engineering are guided by their identification with engineering rather than a homogeneous curriculum acting like a pipeline[13]. In essence, freshman engineering retention might be improved by stronger identification with engineering careers[14]. Studies have shown positive results from efforts in career planning[15] and developing a better understanding of what engineers do[14]. Although teaching engineering design can be challenging[5,16], industry demands "engineers who can design."[16]

Many agree that engineering design needs to involve both divergent and convergent thinking[16]. In brief, divergent thinking seeks to generate as many alternatives as possible and convergent thinking seeks to narrow down options and select the best alternative. Many tools have been developed through educational research, including a Design Teaching and Learning Matrix[17].

Numerous programs report on changes to first year curriculum and some of the best practices include ensuring that students are stakeholders in the process[18], identifying course foci before selecting material[19], combining game-based learning into group projects[20], and introducing students to multiple engineering disciplines[21].

Entrepreneurship is another theme that commonly arises in the literature on freshman engineering courses. In particular, the Kern Entrepreneurial Engineering Network encourages young engineers to take an entrepreneurial mindset when completing projects and some applications have shown promise for increased performance as a result[22].

Background on How the Course was Previously Taught

The freshmen introduction to engineering course, IE 106, is entitled "Engineering Problem Solving" (EPS). Engineering students are required to take the course within their first year. The course was previously taught as a project-oriented class with an emphasis on student engagement and introducing different engineering disciplines; it did not include much technical content. The course had essentially no prerequisites. Since students often took the course along with Calculus I or Pre-Calculus and before they took Physics I, they had limited quantitative skills and science background. The class size was typically large with 80 or more students per section. A call staff with executive background in industry typically taught the course. The students were not challenged and project expectations from the students were not set very high. As a result, more than 90% of the students enrolling in the course received grades of C or higher. The student course evaluations frequently contained comments about the course being helpful in getting acclimated to college life, but not gaining much technical knowledge on engineering. The small group of undeclared, underprepared, but vociferous students usually set the rigor of the course content.

A variety of small projects were fun to work on, but the projects did not require new technical knowledge nor were they good illustrations of the different engineering disciplines represented in the School of Engineering. Significant emphasis was placed on project presentations and reports rather than teaching background information that was relevant to the projects. In summary, the course was heavy on the motivational side, but weak on the engineering knowledge side.

Overview of Changes to the Course

Two things happened in academic year 2012-2013 that drove changes to EPS. First, Southern Illinois University Edwardsville (SIUE) implemented a significant change to its general education requirements that included a new requirement for New Freshmen Seminar (NFS) courses. These courses are designed to increase student retention at the university while helping students adjust to college life and learn about university values. University policy restricts the size of these courses to approximately 30 students. The other significant change affecting EPS was the awarding of a National Science Foundation grant to study retention among engineering undergraduates. The primary focus of this grant was supplemental instruction in calculus, but strengthening EPS was also included in the grant.

The combined effect of these two changes is that an NFS version of EPS was created by a team of full-time faculty and full-time instructors selected because of their strong teaching records. In 2012, the team initially consisted of one member each from electrical, civil, and mechanical engineering and the course was structured around three major projects, one for each discipline. In 2013, a member from industrial engineering was added as well as a corresponding fourth project on industrial engineering. All sections of the course are offered at the same time and the instructors rotate between the sections at different times of the semester. Students taking EPS include civil engineering, mechanical engineering, electrical engineering, computer engineering, and industrial engineering majors. An example semester schedule is shown in Figure 1.

Each instructor teaches a module associated with the project of his or her discipline, covering the necessary basic theory for students to conduct analysis-driven design. The civil engineering project is the design of a small-scale truss bridge. Students learn the basics of structural mechanics and statics. The mechanical engineering project is the design of a tennis ball launcher, where students learn and apply the basics of projectile analysis along with conservation of energy. The electrical engineering project is designing, building, and testing a small wind turbine. Students learn basic circuit analysis during this project. The industrial engineering project is the exploration of production systems for paper airplanes. Students compare single-station and multi-station production cells.

Class Schedule (FR2)

Session 1: Civil Engineering (Statics)

	Tuesday	Thursday
Week 1	Intro to IE 106; Engineering Design Process	Technical Writing 1; Assign First Project
Week 2	Project Lecture 1.1	Project Lecture 1.2
Week 3	Project Lecture 1.3	Project Work
Week 4	Quiz 1	First Competition/ Demonstration (Report Due)

Session 2: Mechanical Engineering (Dynamics)

	Tuesday	Thursday
Week 5	Communication 1; Assign Project 2	Project Lecture 2.1
Week 6	Project Lecture 2.2	Project Lecture 2.3
Week 7	Project Work	Quiz 2
Week 8	Second Competition/Demo	Presentations

Session 3: Industrial Engineering (Production Systems)

	Tuesday	Thursday
Week 9	Technical Writing 2; Communication 2	Ethics; Assign Project 3
Week 10	Project Lecture 3.1	Project Lecture 3.2
Week 11	Project Lecture 3.3	Project Work
Week 12	Quiz 3	Third Competition/Demonstration (Report Due)

Session 4: Electrical Engineering (Circuits)

	Tuesday	Thursday
Week 13	Project Lecture 4.1	Project Lecture 4.2
Week 14	Project Lecture 4.3	Industry Panel
Week 15	Fourth Competition/Demo	Presentations
Week 16	Comprehensive Final Exam	

Figure 1: Example semester schedule

Pedagogical Research Question

The primary question this study seeks to answer is whether or not the changes made to EPS have improved student retention in engineering. Cohorts of students who enroll in the NFS version of EPS will be compared to those who take the traditional, non-NFS version. The percentage of students who persist in engineering will be compared between the cohorts. Persistence in engineering is defined as either graduating from a major in the School of Engineering or being currently enrolled in a major that is within the School.

Analysis and Results

In order to statistically analyze the cohorts, persistence in engineering was given a value of 1 while not persisting was given a value of 0. Students who did not persist in engineering either changed their major or dropped out of SIUE entirely. Each cohort then has an array of 1's and 0's representing student persistence in engineering, which forms a Bernoulli distribution. Bernoulli analysis is based on the fraction of each group receiving a value of 1 and the fraction receiving a value of 0.

For each cohort, the fraction of students persisting in engineering, p_i, was defined as

$$p_i = \frac{\text{(\# of students persisting)}}{\text{(total \# of students in the cohort)}}$$

The total number of students in the cohort is the population size n_i.

Cohorts and a Caveat

This paper will present comparisons for two years of data: students taking EPS in the fall of 2012 and 2013. The NFS and non-NFS cohorts will be compared for each year. There is a caveat that prevents students from 2014 on being used in this analysis at this time. Beginning in the fall of 2014, juniors and seniors in engineering are charged differential tuition. The student information system shared by the office of records and the bursar's office required charging differential tuition as soon as a student declared an engineering major. Therefore, a transitional student status in the information system called Pre-Engineering was created that allows admission to engineering without declaring a major. Analysis of the Pre-Engineering data for Fall 2014 students suggested that this change created anomalies in the data. So, it will not be clear until the 2014 students enter their junior years which students have actually persisted in engineering.

Fall 2012 Cohorts

In the fall 2012 semester, 71 students enrolled in the NFS sections of EPS and 86 students enrolled in the traditional version of the course. Of the NFS cohort, 31 persisted in engineering or

43.7%. For the non-NFS cohort, 33 persisted in engineering or 38.4%. The data is shown in Figure 2. These persistence rates were evaluated based on spring 2016 major/degree earned. If these rates seem low, keep in mind that any student enrolling in the EPS course is counted as intending to major in engineering, even though at least one third of the students never declare an engineering major.

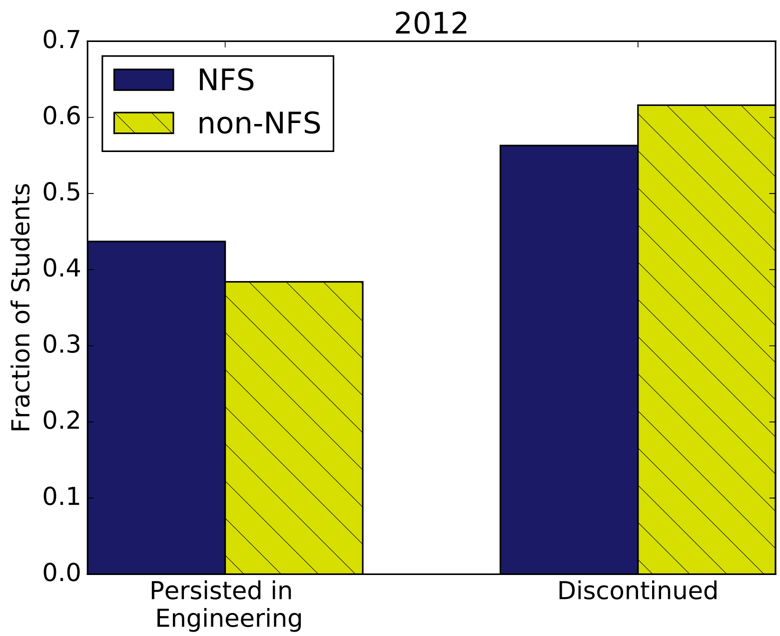

Figure 2: Bernoulli persistence data for 2012 cohort.

While the NFS version has a higher persistence percentage, the statistical significance of this difference needs to be assessed. For this analysis, $n_1 = 71$, $p_1 = 0.437$, $n_2 = 86$, and $p_2 = 0.384$. The statistical significance depends on the z score for the difference $p_1 - p_2$. The null hypothesis says this difference should be zero. The z score measures how many standard deviations away from zero the observed difference is. The null hypothesis analysis also depends on the persistence fraction for both cohorts combined:

$$p = \frac{(p_1 n_1 + p_2 n_2)}{(n_1 + n_2)}$$

For fall 2012,

$$p = \frac{(31 + 33)}{(71 + 86)} = 0.408$$

The formula for the z score is

$$z = \frac{(p_1 - p_2)}{\sqrt{(p(1-p)(\frac{1}{n_1} + \frac{1}{n_2}))}}$$

A z score of 1.96 corresponds to 95% confidence that $p_1 - p_2 \neq 0$. For the fall 2012 data, the z score for NFS vs. non-NFS sections persistence is only 0.671. So, the observed difference in persistence percentage is smaller than one standard deviation and thus, not statistically significant.

Fall 2013 Cohorts

For the fall 2013 cohorts, 74 students enrolled in the NFS sections with 45 persisting ($p_1 = 0.608$), while 62 students enrolled in the non-NFS section with 32 persisting in engineering ($p_2 = 0.516$). These persistence rates were also evaluated based on spring 2016 major/degree earned. The data is shown in Figure3. The z score for $p_1 - p_2$ for 2013 is 1.078. It is also worth discussing the fact that both the NFS and non-NFS cohorts for 2013 have higher persistence rates than the 2012 cohorts. This difference may be due to the 2012 cohort being evaluated over a longer period of time. It will be interesting to see how these two groups compare after 5 or 6 years, when the majority of both groups will have either graduated or discontinued.

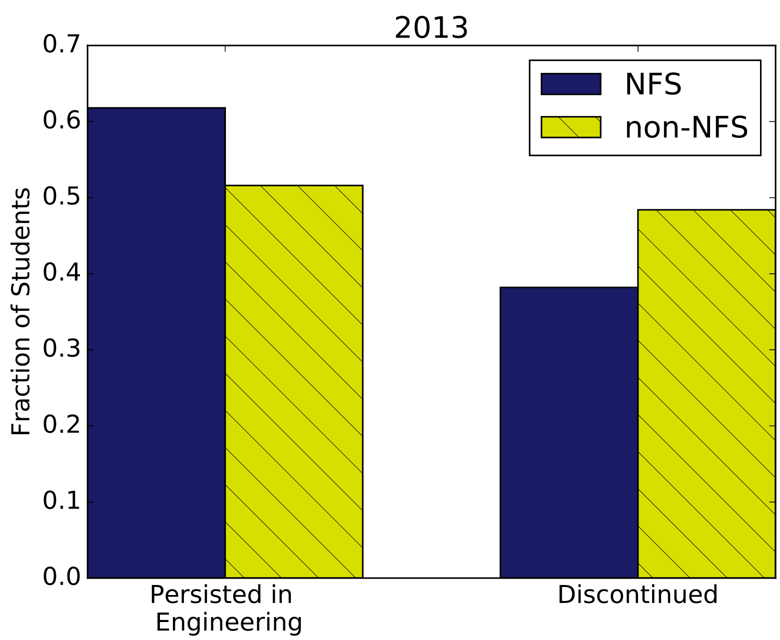

Figure 3: Bernoulli persistence data for 2013 cohort.

The data currently available gives only the students' majors at the time they took EPS their current major in the spring 2016 semester, or the major they graduated with. With the available data, students who took EPS in the fall of 2012 were evaluated on their retention over 3.5 years; whereas the fall 2013 cohort was only evaluated over 2.5 years. Even though the difference between the persistence rates of the NFS and non-NFS rates is encouraging and the difference in 2013 is larger than the difference in 2012, neither of the z scores lead to statistical significance at the 95% confidence level.

The data for the 2012 and 2013 cohorts is summarized in Table 1.

Table 1: Summary of enrollment and persistence data.

Group	students enrolled in EPS	number persisting in engineering	persistence fraction
2012 NFS	71	31	0.437
2012 non-NFS	86	33	0.384
2013 NFS	76	47	0.618
2013 non-NFS	62	32	0.516

Further Analysis

One interesting aspect of the data is that even though the persistence rates for students from the NFS sections are higher, the percentage of students passing the NFS sections is much lower. As mentioned previously, more than 90% of students taking the non-NFS sections of EPS receive grades of C or higher. In 2012, the percentage for non-NFS students receive grades of C was 96.5% while in 2013 it was 93.6%. The percentages for students in the NFS sections are much lower. In 2012, 81.7% of students in the NFS sections received grade of C or higher while in 2013 it was 68.9%. It is particularly interesting that in 2013, the passing percentage for the NFS sections was lower than in 2012 while the persistence percentage is higher. The lower passing percentage for the NFS sections is assumed to be due to the theory introduced into the course and the projects. Although the creation of the NFS version of EPS seems to have marginally increased student persistence in engineering, students who pass the NFS version seem more likely to persist in engineering than students who pass the non-NFS version.

Based on this finding, the previous z score analysis was re-done, filtering out students who received grades of D or worse in EPS. For fall 2012, the NFS cohort changed to $n_1 = 58$ and $p_1 = 0.535$. For the non-NFS cohort, the values changed to $n_2 = 83$ and $p_2 = 0.398$. The resulting 2012 z score is 1.607, which is still short of the 95% confidence interval. The Bernoulli data is shown in Figure 4.

Again filtering out students who received grades of D or worse in EPS for 2013, the NFS cohort data changed to $n_1 = 51$ and $p_1 = 0.843$. For the non-NFS cohort the data changed to $n_2 = 58$ and $p_2 = 0.552$. The resulting 2013 z score is 3.28, which is well above the value of 1.96 required for 95% confidence ($p = 0.001038$). So, it is statistically significant that students in the 2013 cohorts who passed the NFS version of EPS were more likely than students who passed the non-NFS version to persist in engineering majors. The Bernoulli data is summarized in Figure 5. While the NFS version of the course appears to be more challenging, given that a much lower percentage of students receive grades of C or higher, it seems that passing the NFS version is a better predictor of student engineering persistence. Z scores for comparing various groups are summarized in Table 2.

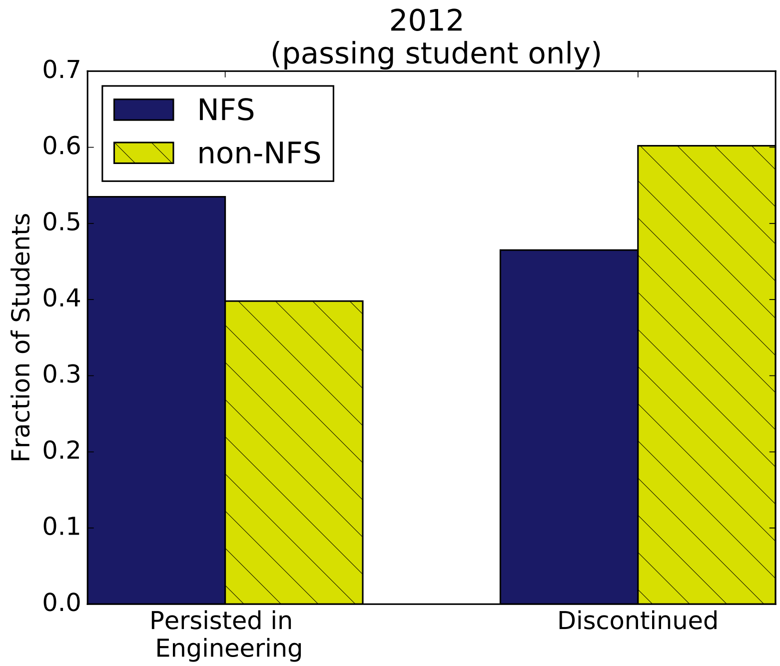

Figure 4: Bernoulli persistence data for 2012 cohorts filtering out students who received grades of D or lower.

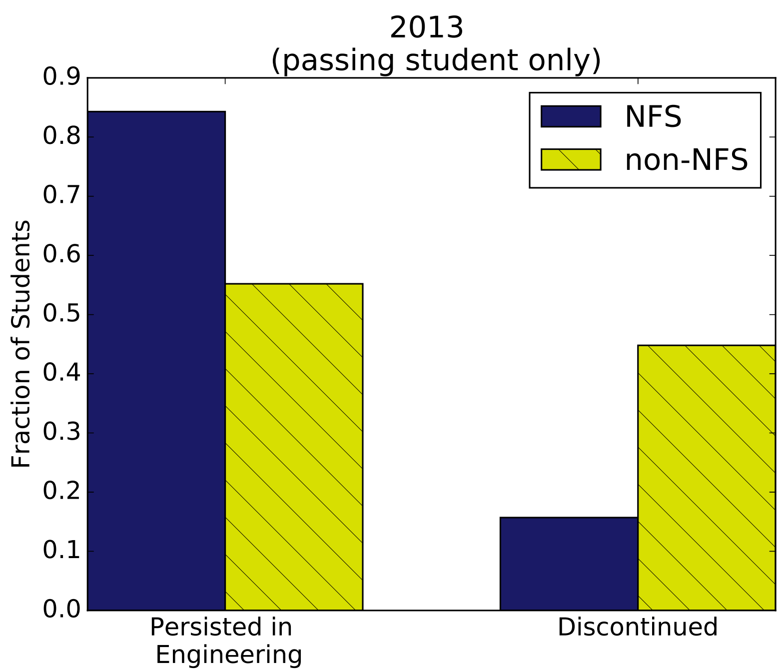

Figure 5: Bernoulli persistence data for 2013 cohorts filtering out students who receieved grades of D or lower.

Table 2: Summary of z scores for comparing various groups.

Persistence Fraction Comparison	z score
2012 NFS vs. non-NFS (all students)	0.6713
2013 NFS vs. non-NFS (all students)	1.208
2012 NFS vs. non-NFS (only passing)	1.607
2013 NFS vs. non-NFS (only passing)	3.394

Freshmen-to-Sophomore Persistence for Declared Engineering Majors

In order to further investigate the differences between 2012 and 2013 persistence data, the freshmen-to-sophomore persistence of students in each cohort was examined. This allows the 2012 and 2013 cohorts to be evaluated over the same length of time. In 2012, there were 38 declared engineering majors in the NFS sections. One year later, 36 of those students were still declared engineering majors. Ultimately, 31 of those students persisted in engineering as of spring 2016. The non-NFS 2012 section had 45 declared engineering majors, with 40 of those persisting the following year. As of spring 2016, 33 of those students have persisted in engineering.

The 2013 cohort showed similar freshmen-to-sophomore persistence rates. The 2013 NFS section had 49 declared engineering majors; 47 of those where still majoring in engineering the following fall. The non-NFS section had 44 engineering majors and 33 of them persisted into their sophomore year.

So, the difference between 2012 and 2013 persistence rates seems to be explained by students in the 2012 cohort discontinuing in their junior years.

Additional Comments

Students in the NFS sections may be at least somewhat better prepared to study engineering than students in the non-NFS sections. The NFS sections are supposed to be reserved for declared engineering majors and the average ACT score for the NFS sections is slightly higher: 25.2 for NFS vs. 23.9 for non-NFS in fall 2012 and 25.4 for NFS vs. 24.2 for non-NFS in fall 2013.

The more generous distribution of letter grades in non-NSF sections might have helped with GPAs and motivated students to persist in engineering. Students may also choose to enroll in the non-NFS sections to get an easier A or B. These factors may complicate the data analysis.

Interpretation of the Results

Students who pass the NFS version of EPS are more likely to persist in engineering then students who pass the non-NFS version of EPS and this difference is statistically significant. This seems to imply that passing the NFS version of the course is a better indicator of success in engineering. Why are students who pass the NFS version of EPS more likely to persist in engineering than students who pass the non-NFS version? There are at least three possible explanations for the difference in persistence among students receiving grades of C or higher in the two versions of EPS.

One possible explanation for the difference in the persistence rate is that the two cohorts of students were different before the class began. Students who are more serious about engineering, more motivated, or better prepared to study engineering may have ended up in the NFS section. This is possible given that the students are to some degree allowed to self-select which section they take. The NFS sections are intended for students who are eligible to declare engineering majors, which requires them to be enrolled in at least pre-calculus. The average ACT score for students in the NFS sections is slightly higher than for students in the non-NFS sections. It is also possible that the most motivated students register for the NFS sections first until those sections fill up. So, it is possible that the students in the NFS sections registered earlier, indicating more motivation or determination to major in engineering. It seems unlikely that self-selection of the version of EPS plays too significant of a role given that students enroll in the summer before their first fall semester. These incoming freshmen would have little opportunity to ask older students about the different versions of the course. This would be particularly true in 2012, which was the first year the NFS version was offered. The NFS version would have been free of reputation at that time. Surveys of the students in both versions of the course could be conducted to assess their attitudes toward engineering and their determination to complete the major.

A second possible explanation for the difference in the persistence rates is that the populations are essentially the same and the NFS version simply does a better job of filtering out students who are less likely to succeed in the engineering curriculum. The NFS version is more rigorous and focuses on analysis-driven design. The engineering analysis taught and expected in the NFS version is inline with expectations in upper division engineering courses. So, getting a grade of C or higher in the NFS version of EPS could be a better indicator of success in the engineering curriculum than getting a grade of C or higher in the non-NFS version.

A third possible explanation is that the populations of students are essentially the same at the beginning of the course, but the NFS version of the course causes increased persistence among the students who take it. This could be the combined effect of smaller class sizes, good instructors, and more rigorous content. Students taking the NFS version of the course could feel more attached to the School of Engineering and better prepared to study engineering by the end of the course, resulting in higher likelihood of persistence in engineering.

Most likely, some combination of these factors ultimately brings about the increase in persistence rates among students passing the NFS version of EPS.

Future Work

Analysis will be done on more cohorts over time as new groups of students reach their junior and senior years. Monitoring these trends over time should strengthen and clarify the observations made to date. Surveys could be used to compare how students in the different versions of EPS feel about engineering. Do students taking the NFS version of EPS have higher confidence in their abilities or show more determination to earn an engineering degree? Do these feelings change from the beginning of the course to the end of the semester?

Conclusions

Introductory engineering courses have been frequently studied and there are a plethora of best practices. Research supports hands-on, project-based, team-based, and experiential learning. To that end, SIUE has redesigned its freshman engineering course into a seminar-style and included several best practices. This study evaluated retention rates between two cohorts of students that either took the redesigned, seminar-style introductory engineering course or the traditional version of the course. The results suggest that there was a significantly higher retention rate for one cohort of students, but only when considering those who earned C's or better. Although this finding does not definitively support that the course change improved retention, the results do suggest that strong performance in the redesigned introductory engineering course is a better indication of student persistence than the same performance in the traditional course.

These findings would be of interest to academicians interested in redesigning cornerstone or introductory engineering courses or those tracking student persistence for their units. Future work will continue to monitor the retention trends in search of deeper conclusions related to the redesigned introductory engineering course and engineering student persistence.

References

[1] Brian F. French, Jason C. Immekus, and William C. Oakes. An examination of indicators of engineering students' success and persistence. *Journal of Engineering Education*, 94(4):419–425, 2005.

[2] Guili Zhang, Timothy J. Anderson, Matthew W. Ohland, and Brian R. Thorndyke. Identifying factors influencing engineering student graduation: A longitudinal and cross-institutional study. *Journal of Engineering Education*, 93(4):313–320, 2004.

[3] Veronica A. Lotkowski, Steven B. Robbins, and Richard J. Noeth. The role of academic and non-academic factors in improving college retention. act policy report. *American College Testing ACT Inc*, 2004.

[4] Cindy P. Veenstra, Eric L. Dey, and Gary D. Herrin. A model for freshman engineering retention. *Advances in Engineering Education*, 1(3):1–31, 2009.

[5] J.M. Paz, M. Cousins, C. D. Wilson, and M. K. Markey. Retention of first-year undergraduate engineering students: Role of psychosocial interventions targeting first-generation college students. In *Proceedings of the 122nd ASEE Annual Conference and Exposition*, Seattle, WA, June 2015.

[6] S. Lorimer and J. A. Davis. Using strengths of first-year engineering students to enhance teaching. In *Proceedings of the 122nd ASEE Annual Conference and Exposition*, Seattle, WA, June 2015.

[7] Matthew Meyer and Sherry Marx. Engineering dropouts: A qualitative examination of why undergraduates leave engineering. *Journal of Engineering Education*, 103(4):525–548, 2014.

[8] Kerry L. Meyers, Stephen E. Silliman, Natalie L. Gedde, and Matthew W. Ohland. A comparison of engineering students' reflections on their first-year experiences. *Journal of Engineering Education*, 99(2):169–178, 2010.

[9] David E. Goldberg and Mark Somerville. The making of a whole new engineer: Four unexpected lessons for engineering educators and education researchers. *Journal of Engineering Education*, 104(1):2–6, 2015.

[10] Daniel W. Knight, Lawrence E. Carlson, and Jacquelyn F Sullivan. Improving engineering student retention through hands-on, team based, first-year design projects. In *Proceedings of the International Conference on Research in Engineering Education*. Honolulu, HI, 2007.

[11] G.W. Bucks, K.A. Ossman, K. Kastner, and F. J. Boerio. First-year engineering courses effect on retention and workplace performance. In *Proceedings of the 122nd ASEE Annual Conference and Exposition*, Seattle, WA, June 2015.

[12] Joseph A. Raelin, Margaret B. Bailey, Jerry Hamann, Leslie K. Pendleton, Rachelle Reisberg, and David L. Whitman. The gendered effect of cooperative education, contextual support, and self-efficacy on undergraduate retention. *Journal of Engineering Education*, 103(4):599–624, 2014.

[13] Reed Stevens, Kevin O'Connor, Lari Garrison, Andrew Jocuns, and Daniel M. Amos. Becoming an engineer: Toward a three dimensional view of engineering learning. *Journal of Engineering Education*, 97(3):355, 2008.

[14] Stephen Rippon, James Collofello, and Robin R. Hammond. Omg! that's what an engineer does?: Freshmen developing a personal identity as an engineer. In *119th ASEE Annual Conference and Exposition*, San Antonio, TX, 2012.

[15] S. Peuker and N. A. G. Schauss. Improving student success and retention rates in engineering: An innovative approach for first-year courses. In *Proceedings of the 122nd ASEE Annual Conference and Exposition*, Seattle, WA, June 2015.

[16] Clive L. Dym, Alice M. Agogino, Ozgur Eris, Daniel D. Frey, and Larry J. Leifer. Engineering design thinking, teaching, and learning. *Journal of Engineering Education*, 94(1):103–120, 2005.

[17] David P. Crismond and Robin S. Adams. The informed design teaching and learning matrix. *Journal of Engineering Education*, 101(4):738–797, 2012.

[18] J.A. Weitzen, M. M. Rashid, S. Johnston, E. L. Maase, , and D. J. Willis. A methodology for restructuring our first year introduction to engineering sequence at university of massachusetts lowell. In *Proceedings of the 122nd ASEE Annual Conference and Exposition*, Seattle, WA, June 2015.

[19] D. Reeping and K.J. Reid. Application of and preliminary results from implementing the first-year introduction to engineering course classification scheme: Course foci and outcome frequency. In *Proceedings of the 122nd ASEE Annual Conference and Exposition*, Seattle, WA, June 2015.

[20] D. D. Anastasio, M. Chwatko, D. D. Burkey, , and J. R. McCutcheon. A first-year project-based design course with management simulation and game-based learning elements. In *Proceedings of the 122nd ASEE Annual Conference and Exposition*, Seattle, WA, June 2015.

[21] M. J. Mohammadi-Aragh, J. Warnock, A. Barton, R. W. Sullivan, B. B. Elmore, , and J. N. Moorhead. Hybrid engineering matriculation model to promote informed engineering-major selection decisions. In *Proceedings of the 122nd ASEE Annual Conference and Exposition*, Seattle, WA, June 2015.

[22] J.A. Riofrio, R. Gettens, A. D. Santamaria, T. K. Keyser, R. E. Musiak, and H. E. Spotts. Innovation to entrepreneurship in the first year engineering experience. In *Proceedings of the 122nd ASEE Annual Conference and Exposition*, Seattle, WA, June 2015.