New Orleans JAZZED about Engineering Education

Paper ID #16219

Assessing Impact of Engineering Projects in Community Service on Engineering Freshmen Enrolled in Pre-Calculus

Ms. Magdalini Z. Lagoudas, Texas A&M University

Magda Lagoudas, Executive Director for Industry and Nonprofit Partnerships, Instructional Associate Professor, Dwight Look College of Engineering, Texas A&M University. Mrs. Lagoudas holds a BS and MS in Mechanical Engineering. She worked for the State of New York and industry before joining Texas A&M University in 1993. Since then, she developed and taught courses in the Departments of Mechanical Engineering and Engineering Technology. In 2001, she joined the Spacecraft Technology Center as an Assistant Director where she was responsible for the structural and thermal analysis of payloads. She served as Director of the Space Engineering Institute and in 2010 she accepted a position with the Academic Affairs office of the Dwight Look College of Engineering where she oversaw outreach, recruiting, retention and enrichment programs for the college. Since 2013, she serves as the Executive Director for Industry and Nonprofit Partnerships with responsibilities to increase opportunities for undergraduates engineering students to engage in experiential learning multidisciplinary team projects. These include promoting capstone design projects sponsored by industry, developing the teaching the Engineering Projects in Community Service course, and developing curricular and co-curricular programs at the Engineering Innovation Center which promote innovation and entrepreneurship among engineering students and in collaborations with other colleges on campus and partnering with other institutions across the country.

Dr. Kristi J. Shryock, Texas A&M University

Dr. Kristi J. Shryock is an Instructional Associate Professor in the Department of Aerospace Engineering and Executive Director of Interdisciplinary Engineering in the Look College of Engineering at Texas A&M University. She received her BS, MS, and PhD from the College of Engineering at Texas A&M. Kristi works to improve the undergraduate engineering experience through evaluating preparation in mathematics and physics, incorporating non-traditional teaching methods into the classroom, and engaging her students with interactive methods.

Engaging Freshman Enrolled in Pre-Calculus in Engineering Projects in Community Service

Abstract

This work-in-progress describes a novel approach to support freshman engineering students entering college with low math competencies in pre-calculus. Institutions across the nation are making significant efforts to develop K-12 programs and summer camps to recruit more ethnic minorities into engineering to better support the growing needs for diversity in industry workforce. However, while a diverse freshman-engineering cohort is essential, it is even more important that schools provide students with adequate support to be successful in their freshman year and thus increase their chances to be retained and graduate with an engineering degree. In particular, first generation and low-income students may enter college without proper academic preparation with fundamentals in mathematics, which may lead to low academic performance during their first year in engineering and impact their retention in engineering. To address this issue, engineering schools are investing resources in developing and offering remediation programs to ensure underrepresented minority students acquire the necessary foundational skills to be successful in their first calculus, physics and engineering courses in college.

In this large public institution, all incoming engineering freshmen are required to take a math placement exam, which determines if they are calculus ready for their first mathematics course. This work-in-progress describes interventions, such as co-enrollment of students in a pre-calculus and engineering projects in community service courses, to assist students who scored very low on this exam in building a mathematical foundation with an engineering framework. At the end of fall semester, students had improved pre-calculus skills (13.8 points) and 86.4% were retained in engineering. The findings of this study will provide further contributions to research on the retention of students who enter engineering requiring remediation in mathematics.

Introduction

This study is focused on 66 freshmen who scored very low on their math placement exam, earning a score even below the recommended level for placement into pre-calculus. The same students were advised to enroll in a one-credit hour project-based course with focus on engineering projects for community service. The one-credit hour course engaged students in two major team projects to provide them with an opportunity to experience the engineering design process and engineering tools. The first project was the Raptor Reloaded project, which involved 3D printing an assembly of a mechanical hand, assembling the parts, and submitting the finished hand to the sponsor organization, e-NABLE, to be delivered to a person with a need for the hand. The second project focused on a need identified by each student team with emphasis on an engineering project to serve the community around our campus. At the same time, the students were enrolled in an intensive four-credit hour engineering mathematics fundamentals (pre-calculus) course that met four days a week. The focus of the course was engineering math skills with an intent of having the students be calculus ready at the end of the semester. Topics covered included algebra and trigonometry skills necessary for success in a subsequent engineering calculus course. In addition, students enrolled in a general chemistry for engineers course.

The co-enrollment of these students led to the central premise of this work: Is it possible to positively impact (i) the academic performance of students co-enrolled in these two types of courses, (ii) the persistence in engineering after the first semester and in subsequent semesters, and (iii) the demographics of engineering students persisting in engineering after one semester? This paper looks at the first offering of these courses as a unit for students who lack a solid mathematical foundation. In this paper, courses, student experiences with each project, and student outcomes at the end of the semester with focus on grades, skills attainment, course placement in engineering, and retention in engineering for the spring semester will be described.

Background

The importance of increasing quality and quantity of engineering graduates in the United States has been well documented[1-3]. Furthermore, there is extensive literature studying the retention and persistence of engineering students[4-7]. The literature also includes studies focusing on retention and persistence of women in engineering[5] as well as retention and persistence of underrepresented racial/ethnic minority students[8-10].

There is also literature addressing the relationship of mathematics to success in engineering[11,12]. An area where substantial improvements can be made is with students who enter an engineering major in college but need to first improve their foundation in mathematics before potentially succeeding in a first calculus course[13]. While the percentage of students who report a need for remediation in mathematics as entering college students greatly varies depending on the particular institution, it is not uncommon to see averages as high as 15-30%[13,14]. Statistics collected by faculty in the mathematics and engineering departments at institution show that engineering undergraduate students who begin their college mathematics sequence in a pre-calculus type course persist at much larger rates than students who enroll in calculus their first semester. While the literature addresses pre-calculus for engineers type courses[13,15] and implementation of service-learning projects in the engineering curriculum[16-24], what the authors did not find was research related to co-enrollment in a major team based projects course utilizing the engineering design process, engineering tools, and an intensive engineering mathematics fundamentals course for students whose mathematics foundation is very weak.

Methods

The study included 66 freshman engineering students at institution who scored very low on an entering mathematics placement exam (MPE). All undergraduate students are required to take the MPE before enrolling in their first semester of classes at institution. This test was constructed in-house by the mathematics department at institution and has been refined and validated over the years. Students complete this assessment during late spring or early summer before their new student orientation. For engineering students, the MPE consists of 33 questions, and the score received on the MPE determines whether the student enrolls in pre-calculus or calculus I their first semester. The MPE for engineering consists of six topics, including: exponential and logarithms, polynomials, graphing, functions, trigonometry, powers, and problem solving. A minimum score of 22 is required to enroll in calculus I. While not an official minimum requirement, the mathematics department at institution advises a minimum MPE score of 15 to enroll in pre-calculus. Sixty-six students in the entering freshman engineering class scored lower

than a 15 on the MPE for fall of 2015. All 66 students were advised to enroll in a one-credit hour project-based course with a focus on engineering projects for community service, a four-credit hour engineering mathematics pre-calculus course, and a four-credit hour freshman general chemistry for engineers course. Participation in two projects in the engineering projects course as well as course grades in both courses and persistence in engineering was evaluated.

Course Interventions

EPICS course description

Engaging freshman in service learning projects as part of the freshman engineering curriculum has been studied and the impact of it has been identified as developing awareness of engineering in our society, engineering identity and overall retention in engineering[16-23]. Additional outcomes may include developing skills in team collaboration and communication. Besides the benefits, literature[24] points out that a fundamental challenge in developing fulfilling and rewarding experiences for each student is the identification of appropriate community partners and projects. In this study, we describe a one credit hour service-learning course designed for entering freshman with MPE scores below 15 and explore potential impact. The course was developed and offered for the first time in Fall 2015 semester to 79 entering freshman. While 66 of the 79 students were students with MPE scores below 15, the remaining 13 students were enrolled in the course for other reasons, including interest and needing one more credit hour for full-time status. The learning outcomes of the course include experience in applying engineering skills to solve real-world problems, understanding of the design process, multidisciplinary thinking, team collaboration, communication and appreciation of the impact of engineering on our society. Students met once a week for fifty minutes and from the start students were assigned in teams of four. The class was designed around three modules (Design Process, Team Collaborations, Communications) and two major team projects. The design process module covered traditional material such as need statement, project scope, design requirements, design concept generation and evaluation, baseline design, milestones and schedule but also introduced students to the concepts of human centered design. Students had the opportunity to practice these skills on two major projects. For team collaboration, besides in-class presentations on phases of team formation, each student team was given a copy of the Five Dysfunctions of a Team book as a reading assignment followed by an in-class discussion and individual written reflection assignment. Students practiced team collaboration skills by working in teams throughout the course on the projects. Finally, the communication module included presentations and videos on effective communications and e-portfolios. Students practiced communication skills with technical reports, in-class presentations, and videos. Below we describe the two major projects.

Project I – The first project was focused on the Raptor Reloaded hand, shown in Fig. 1 and 2. Raptor Reloaded is a design developed by collaborators of E-NABLE[25], a global network of over 5,000 volunteers which provides interested volunteers access to designs and detailed instructions on how to print and assemble the parts for a functional "hand" which will be donated to a child or adult missing the lower part of their hand. Freshman in the class were assigned to teams of four and each team was assigned to build a Raptor Reloaded hand, which was unique in its size and orientation (left vs right). The first part of the project asked students to download the files for the Raptor Reloaded design, import them in CAD software of their choice, scale the assembly to different sizes, check units, and manipulate the assembly for right or left hand orientation. This

was by far the most challenging part of this project for the students. Our assumption was that students will have some experience with CAD from high school but the reality was that very few students had used CAD software before. To address the issue, we offered several training sessions on CAD and 3D printing. The second part of the project focused on using 3D printers at the college makerspace to make all parts of the assembly, which proved to be more exciting for students than manipulating geometries. Students were able to understand how 3D printing works, the process of generating STL files, types of materials available, and the concept of infill. Furthermore, at this step students were introduced to the college makerspace, which offers resources on fabrication (beyond 3D printing), electronics, programming, access to parts, collaboration spaces, and conference rooms. The last phase of the project included assembling the parts to make the "hand" which provided students a great hands-on experience, as they were required to assemble the parts in a fully functional hand ready to be shipped to a user. At the end of the project, twenty unique hands were shipped to E-NABLE for distribution to clients.

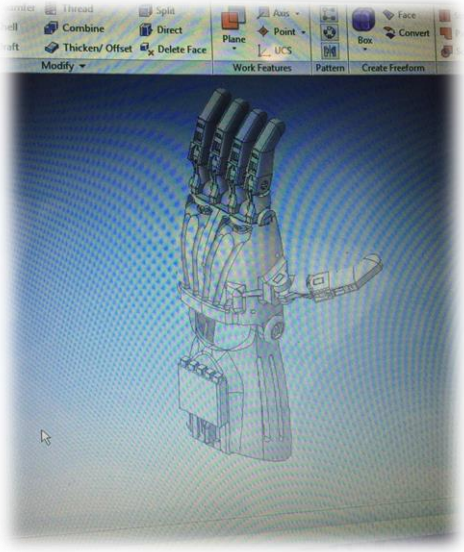

Figure 1 & 2. Raptor Reloaded finished prototype and CAD image.

Project II – In the second project, each student was asked to explore project ideas around our campus and submit them for consideration with his /her team. Then, each team evaluated all project ideas and identified one idea to pursue for the remaining of the semester. The main criteria for selecting the project were: 1) it must be a design project and 2) it required technical competencies at the level of freshman. Students were very innovative in identifying potential project topics but also experienced the challenges in team dynamics more so in this project than the first project. The reason for this is that Project I expected students to collaborate and perform tasks, which were well defined. In Project II students had to evaluate different ideas, identify one idea to pursue, and define a project plan for the remaining of the semester. The success of the second project was based on having a functional team which proved challenging for some. During the second project, in-class lectures focused on developing project need statements,

identifying design requirements and functions for the expected solution, developing and evaluating design concepts, developing a baseline solution and project plan, and meeting their project plan milestones. Table 1 lists all the projects titles student teams pursued as part of the second project. They represent a wide range of applications, which reflect different student interests.

Table 1. Project Titles	
Interactive Maps	Bike Rack
Drip Irrigation	Automated Animal Feeder
SeKure Bike	Bust Stop Awning
Smart Lifejacket	F.L.O.P.
Board-Based Transportation Lock	Methane Collection Box
Mace Case	Interactive Display
Rent n' Return Umbrella	The Future of Parking
Power Walks	Hammock Dispenser
Don't Panic Alert Button	Solar Powered Charging Stations
Spread WiFI	Fingerprint Scanners for Dorms

Overall, most teams did very well on their projects, pursued innovative approaches to solving problems they face around campus, and seemed to enjoy the process as evident by the end of semester project videos. During the project students were encouraged to identify faculty and staff on campus to discuss their projects and receive input on their ideas. This process allowed students to establish connections with university staff beyond their course instructors and also excited them about the possibility of them being able to solve a problem on our campus and make an impact as freshman.

The authors would like to share some observations which might be of value to others considering implementing service-learning projects in freshman year. First, projects such as the Raptor Reloaded project, which are well defined, are much easier to incorporate in class. While students may not have the skills for CAD or 3D printing the concepts are not very challenging to understand and with some training students are able to complete the project. The second project presented several challenges to students such as: *what could we possible do as freshmen, how do we define a good project, this is a cool idea and we want to build it- no matter what others may have done in this area.* Some of these are challenges even for upper division who may have an easier time dealing with them. In addition, as an open-ended project Project II was by nature much more challenging to students and required significant guidance by faculty and graduate student mentors.

Out of the 66 students co-enrolled in the service-learning course and pre-calculus, nine have changed to non-engineering majors, four female and five male students. Investigation of how these students performed in the service-learning course indicates that eight of the nine students had a final grade of B in the course and one had C. While the impact of this class to the student's overall academic performance and retention in engineering will require further investigation, we believe the class provided students an opportunity to engage in engineering projects, gain

firsthand experience on the impact of engineering in our society, and start considering themselves as future engineers.

Engineering mathematics fundamentals course description
The engineering mathematics pre-calculus course was developed to address mathematics skills needed for engineering calculus I. As mentioned previously, students in this course did not score high enough on the MPE to enter pre-calculus. All engineering curricula at institution require calculus I as the first mathematics course. Students who do not begin in calculus I are not able complete many of the required first semester courses, effectively causing the student to be behind in their degree program. The intent of the four credit hour course was to prepare students who were not pre-calculus ready and give them the skills to enter calculus I directly following this course. The course was organized around a set of tasks intended to improve foundational algebra, geometry, and trigonometric skills and knowledge. In addition, problems were formulated with engineering context to invoke higher-level mathematical reasoning skills essential for calculus and engineering courses.

The structure of this course was comprised of two, 50-minute lecture-type instructional periods in which all 66 students were enrolled. In addition, students were split into three recitation sections where they attended two 65-minute weekly recitation sessions. The recitation sessions were taught by recitation leaders, upper-level engineering students. Also, additional help sessions were held three times a week to provide further practice for interested students. Students completed both in-class homework assignments and on-line homework and quiz assignments for additional instruction and reinforcement. Students were divided into four-member teams, which were common to their particular recitation session. This allowed students to work in their teams during their sessions. Because additional students beyond the 66 students in the cohort in this study (STUDY) were enrolled in the engineering projects course, common teams were not consistent between the two courses in this study. This is an area to consider in future implementations of the course.

Student Demographics

Overall Fall 2014 cohort versus Fall 2015 cohort
This study was based on a cohort from the Fall 2015 semester. Before providing demographics of the students in the study, the overall engineering Fall 2015 cohort was compared to Fall 2014 cohort to see if there were any sizable differences. The total number of students in the Fall 2014 cohort was 2923, and the total number of students in the Fall 2015 cohort was 2967. As you can see from Figure 1 percentages of students in each of the four categories were compared. Percentages of students who were first generation in college, female, Hispanic, and Black, were approximately the same between the two fall semesters. While there were growths in each of the four categories from Fall 2014 to Fall 2015, the percentage of the total undergraduate engineering population was similar for the four groups.

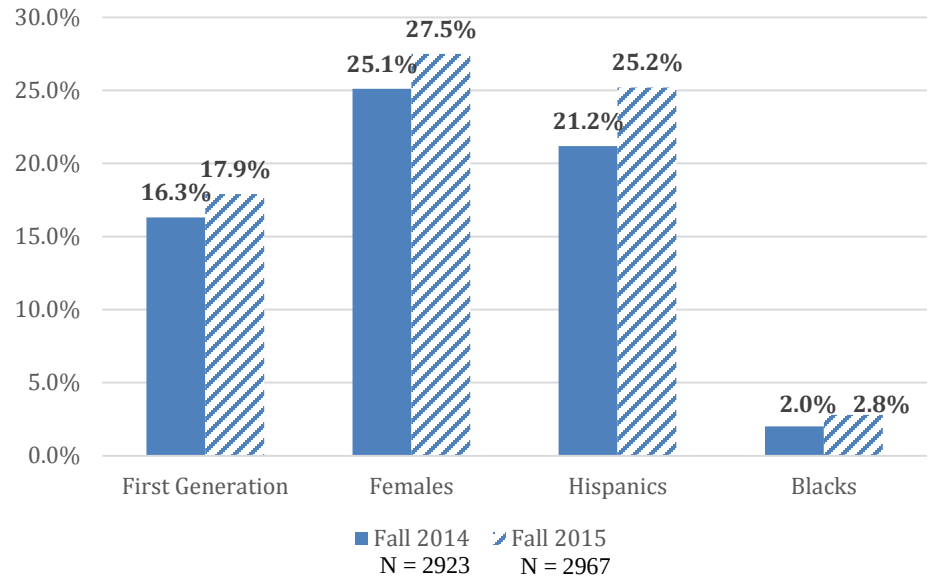

Figure 3. Comparison of students in the Fall 2014 and Fall 2015 cohorts.

Students in study

The 66 students in the study were a subset of the fall of 2015 cohort shown in Figure 3. As mentioned previously, the students were enrolled in this course after scoring less than 15 on the MPE. The demographics of these students are given in Table 2 in the second column. The third column contains demographics for the entire population of first-time in college engineering students (ENGR). As can be seen from the table, there are several large differences in the cohort compared to the overall undergraduate Fall 2015 cohort. These areas include: much lower average SAT math score, much higher percentages of first generation in college, regents scholars, Hispanic students, and Black students. Regents scholars at institution are students who are first generation in college and have a combined family income of less than $40,000. Another interesting statistic is the high school percentile comparisons. As shown in the table, the average high school percentile is actually slightly higher for the sample in the study as opposed to the overall undergraduate engineering population.

Table 2. Demographics of students in STUDY vs ENGR cohort.

	Fall 2015 STUDY cohort	**Fall 2015 ENGR cohort**
Sample size	66	2967
SAT average math score	543.8	652.2
First generation	37.9%	17.9%
Regents scholars	22.7%	7.4%
Females	27.3%	27.5%
Hispanics	34.8%	25.2%
Blacks	9.1%	2.8%
High school percentile	93.2%	90.4%

Outcomes

After evaluating the project as a whole, further investigation needs to be done. One purpose of the study is to evaluate the persistence of students in engineering after the first semester and in subsequent semesters. Because this is the first instance of the course being offered, only a one-semester persistence in engineering can be compared. When a one-semester retention in engineering of the cohort of 66 students was compared, 86.4% are still majoring in engineering in Spring 2016 versus 13.6% who have officially changed majors outside of engineering. Out of all first-time in college students in engineering for Fall 2015, 92.7% have remained in engineering for Spring 2016. This percentage is not unlike the Fall 2014 cohort, which had 93.3% first semester retention of its engineering undergraduate students. While the 13.6% of students from the cohort are all still pursuing degrees at the university, it is seen as a loss for engineering.

To best evaluate the academic performance of students co-enrolled in these two courses, student success is measured in two different ways. The first item is to look at the overall first semester average grade point average (GPA) for students. As shown in Figure 4, GPA is shown for students in the STUDY and ENGR groups. Both bars display the GPA for the subset of students in each of the groups who still remain in engineering for the Spring 2016 semester. The GPA for the 57 students (out of the 66 total in the cohort) in the study is 2.56, while the GPA for all additional engineering students remaining in engineering is 2.99. When the subset of only the nine students from the study who left engineering after the fall semester is evaluated, the GPA of this group is 2.76, which is higher than the STUDY group as a whole. This is also shown on the left hand side in the figure. An in-depth evaluation is needed with this group to determine why they left engineering.

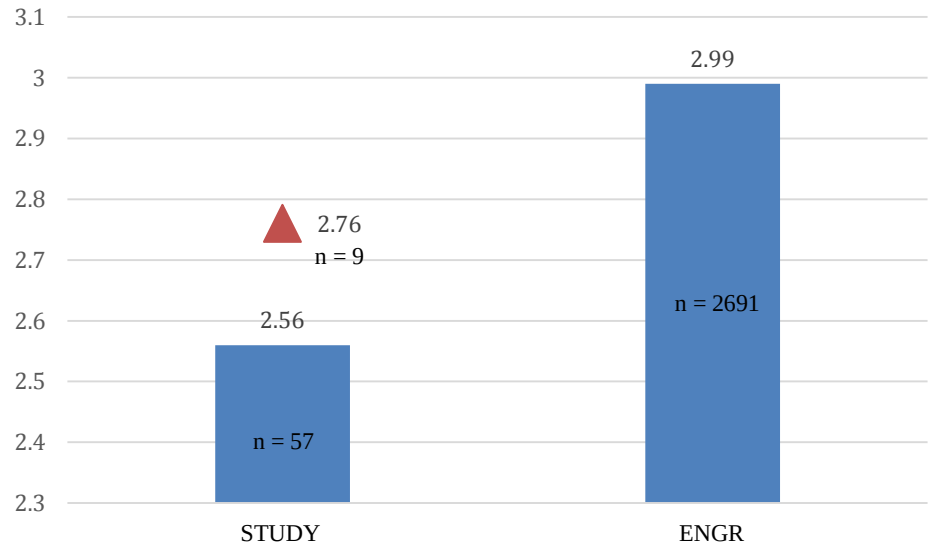

Figure 4. Average grade point average of students in STUDY vs ENGR cohort.

A second measure of academic performance is to evaluate scores on the MPE when taken at the end of the course. As mentioned previously, students must earn at least a score of 22 on the MPE to enroll in engineering calculus I at the institution. The average MPE score prior to the start of

the fall semester was 11.8 points with a minimum score of 5 and a maximum score of 14 being earned. Students were required to retake the MPE at the end of the fall semester, and the average MPE score at the end of the semester rose to 25.6 points. This is seen as a significant improvement.

To address the third question posed earlier regarding demographics of engineering students persisting in engineering after one semester, percentages of students in each of the demographic categories studied: first generation in college, females, Hispanics, and Blacks is compared as shown in Figures 5-8. For each of these four figures, percentages of the original cohorts for each population are provided on the left hand side bars. Originally, there were 66 students in the STUDY cohort and 2967 students in the ENGR cohort. The set of bars to the right in each of the figures then depicts the percentages of each population remaining after one semester. The population sizes in these cohorts are 57 for STUDY and 2691 for ENGR groups.

As shown in Figure 5, the STUDY group fares better than the ENGR group in regards to first generation in college students. Not only is there a much higher percentage of first generation in college students in the initial STUDY cohort compared to the ENGR group but also a higher percentage of first generation students in the STUDY cohort after one semester still remains. Even though three first generation in college students left engineering after one semester from the original STUDY group, the 22 remaining first generation students from the original cohort compose a larger percentage of the remaining 57 students from this cohort as is shown in the figure. However, the percentage of first generation students still in engineering after one semester in the ENGR cohort contains a slightly smaller percentage of the remaining students than the original ENGR group.

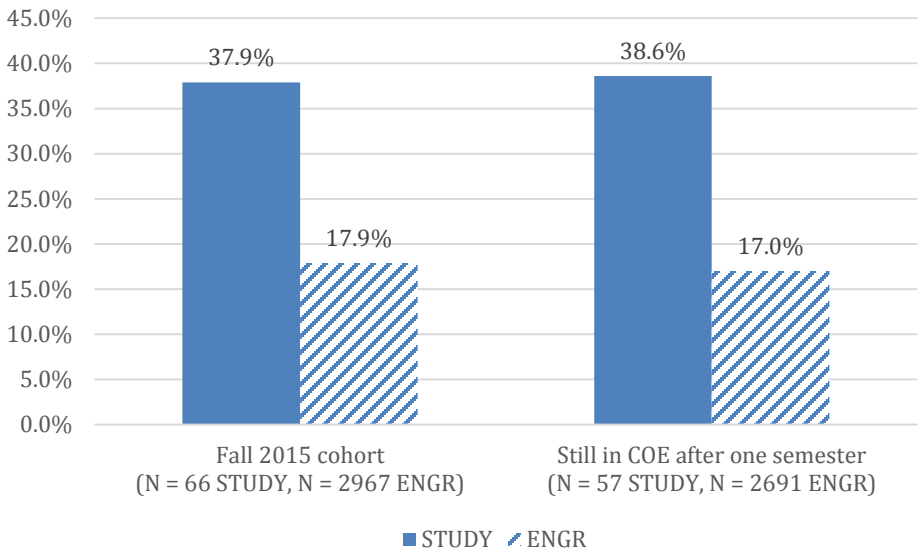

Figure 5. Percentages of first generation college undergraduate students in fall of 2015 cohort and cohort remaining after one semester.

Figure 6, however, depicts that a much larger percentage of female undergraduate engineering students did not persist in engineering after the first semester from both the STUDY and ENGR cohorts. The entering percentages of females in the two cohorts is similar, and both groups

experience a loss in female students, resulting in females comprising smaller percentages of the students persisting after one semester in both cohorts. In the case of the STUDY group, four female students from the original 18 females left engineering after one semester.

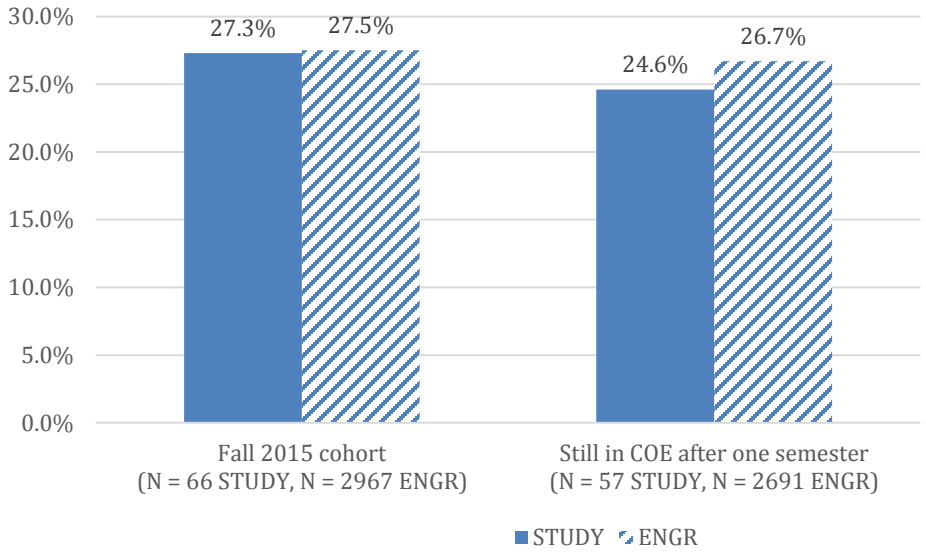

Figure 6. Percentages of female undergraduate students in fall of 2015 cohort and cohort remaining after one semester.

As shown in Figure 7, the original STUDY cohort has a larger percentage of Hispanic undergraduate engineering students than the ENGR group. After one semester, the percentage of Hispanic students remaining in the STUDY group encompasses a larger portion of this cohort than the original set of students in the STUDY cohort. Only two of the original 23 Hispanic students in the STUDY cohort did not persist after one semester. The percentage of Hispanic undergraduate students remaining after one semester in the ENGR cohort is slightly below (25.2%) the original percentage in the cohort (25.0%) as shown in the figure.

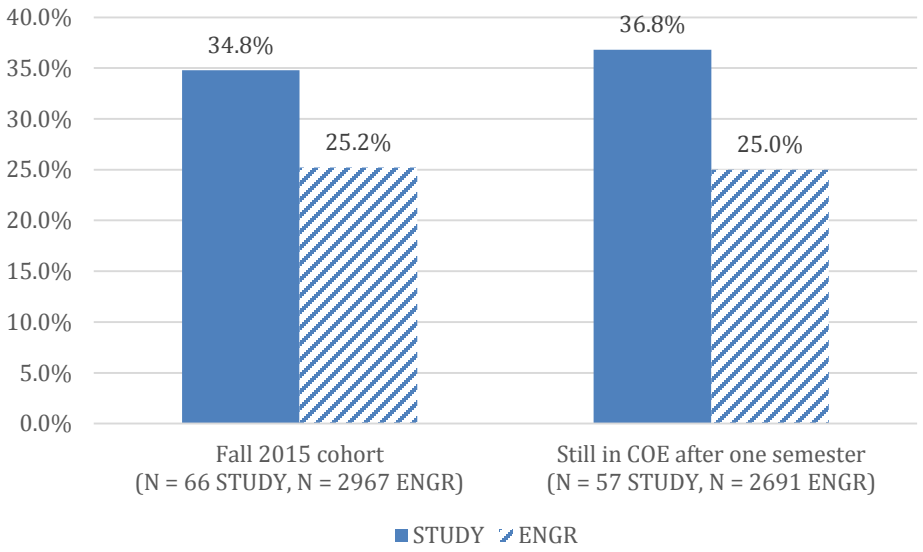

Figure 7. Percentages of Hispanic undergraduate students in fall of 2015 cohort and cohort remaining after one semester.

Figure 8 displays the persistence of Black undergraduate engineering students for the STUDY and ENGR groups. All six Black students from the original STUDY group are retained in engineering for spring semester. This results in an increase in the percentage of Black students remaining in the STUDY cohort after one semester. This increase differs from what the ENGR group experienced.

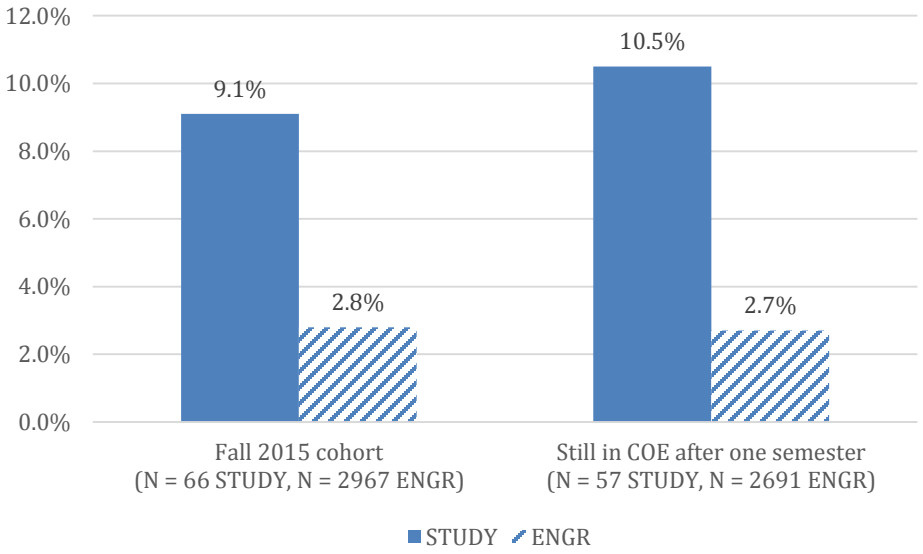

Figure 8. Percentages of Black undergraduate students in fall of 2015 cohort and cohort remaining after one semester.

To determine how one semester persistence in engineering relates to previous semesters, similar comparisons were made from the fall of 2014 cohort. When the percentages of first generation in

college, female, Hispanic, and Black undergraduate engineering students were compared, the values of students retained after one semester were relatively the same for each of the populations in comparison to the incoming number.

Investigation into the performance in the engineering mathematics fundamentals course for the nine students who did not persist in engineering indicates that five of the students earned a final grade of A in the course with one B grade, two C grades, and one who officially dropped the course prior to the end of the course. An in-depth investigation will need to be done in this respect.

Of the 66 students enrolled in this pre-calculus course, ten students earned grades of D or F, and three students officially dropped the course before the end of the semester. As mentioned previously, a passing grade in this course was not required to enter calculus I. Students only needed to earn at least a score of 22 on the MPE. Therefore, eight of the ten students earned high enough scores to enroll in calculus I. Two of the students did not earn high enough MPE scores. One of these two students enrolled in a regular pre-calculus course; another student decided not to enroll in a mathematics course during the spring semester. Of the three students who officially dropped the course prior to the end of the semester, one student changed his/her major, and another student enrolled in a course outside of an engineering mathematics course. One additional student scored high enough on the MPE to enroll in calculus I.

Just as students could fail the engineering mathematics fundamentals course and still pass the MPE, students could also pass the course and fail to earn a score of at least 22 on the MPE. Three students fell into this category, with two of the students not enrolling in a mathematics course, one student changing his/her major, and one student enrolling in pre-calculus. As this was the first time this new course was offered, additional evaluation will need to be done to determine any correlation for these cases.

Conclusions

This work-in-progress paper presented a unique approach for academic growth and likely persistence of freshman engineering students entering college unprepared to enroll in Calculus I. Preliminary data suggest that the approach may have a positive impact on the persistence of ethnic minorities but not females, which was common for both the students in the study and all engineering students entering with first time in college status in fall of 2015. Future plans include further developing the two courses, connecting service-learning projects to math subjects taught in the pre-calculus course, and incorporating a team structure that correlates between both courses.

Bibliographic Information

1. Committee on Science Engineering and Public Policy. (2006). *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*. Washington, D.C.: National Academies Press.
2. National Academy of Engineering. (2004). The Engineer of 2020. Washington, D.C.: National Academies Press National Academy of Engineering. (2005).
3. Educating the Engineer of 2020: Adapting Engineering Education to the New Century. Washington, D.C.: National Academies Press.

4. Ohland, M. W., Sheppard, S. D., Lichtenstein, G., Eris, O., Chachra, D., & Layton, R. A., Persistence, engagement, and migration in engineering programs, *Journal of Engineering Education*, 2008, Vol. 97, No. 3, pp. 259-278.
5. Marra, R. M., Rodgers, K. A., Shen, D., & Bogue, B., Leaving engineering: A multi-year single institution study, *Journal of Engineering Education*, 2012, Vol. 101, No. 1, pp. 6-27.
6. Atman, C. J., Sheppard, S., D., Turns, J., Adams, R. S., Fleming, L. N., Stevens, R., Streveler, R. A., Smith, K. A., Miller, R. L., Leifer, L. J., Yasuhara, K., & Lund, D., Enabling engineering student success: The final report for the center for the advancement of engineering education. CAEE-TR-10-02. 2010, Center for the Advancement of Engineering Education: Seattle, WA, USA.
7. Seymour, E., & Hewitt, N. M., *Talking about leaving: Why undergraduates leave the sciences*, 1997, Boulder, CO,USA: Westview Press.
8. Marra, R. M., Rodgers, K. A., Shen, D., & Bogue, B., Women engineering students and self-efficacy: A multi-year, multi-institution study of women engineering student self-efficacy, *Journal of Engineering Education*, 2009, Vol. 98, No. 1, pp. 27-38.
9. Lord, S. M., Layton, R. A., & Ohland, M. W., Trajectories of electrical engineering and computer engineering students by race and gender, *IEEE Transactions on Education*, 2011, Vol. 54, No. 4, pp. 610-618.
10. Lord, S. M., Camacho, M. M., Layton, R. A., Long. R. A., Ohland, M. W., & Wasburn, M. H., Who's persisting in engineering? A comparative analysis of female and male Asian, black, Hispanic, Native American, and white students, *Journal of Women and Minorities in Science and Engineering*, 2009, Vol. 15, No. 2, pp. 167-190.
11. Herzog, S. (2005). Measuring determinants of student return vs. dropout/stopout vs. transfer: A first-to-second year analysis. *Research in Higher Educations, 46*(8), 883-928.
12. National Science Board. (2004). *Science and engineering indicators*. Retrieved from www.nsf.gov/statistics/seind04/pdfstart.htm.
13. Shryock, K. J., & Srinivasa, A. R., & Froyd, J. E. (2011, June), *Preparing Engineering Students to Take a Calculus Course: An Engineering-Oriented Approach* Paper presented at 2011 Annual Conference & Exposition, Vancouver, BC. https://peer.asee.org/18704
14. Moore, D., and Orengo-Aviles, M. (1999). Project precalculus. *Proceedings of the 1999 Frontiers in Education Conference.*
15. Ennis, T. D., & Sullivan, J. F., & Louie, B., & Knight, D. (2013, June), *Unlocking the Gate to Calculus Success: Pre-Calculus for Engineers - An Assertive Approach to Readying Underprepared Students* Paper presented at 2013 ASEE Annual Conference, Atlanta, Georgia. https://peer.asee.org/22670
16. Widmann, J.M., Self, B. P., Schuster, P., Development and Implementation of a Long-Term Freshman Service Project: The Design and Deployment of an Engineering Outreach Experience for Underserved Populations, ASEE, 2015, Seattle, WA.
17. Freeman, S. F., et al, Service-Learning vs. Learning Service in First year Engineering: If We Cannot Conduct First Hand Service Projects, is it Still of Value?, 2015 ASEE, Seattle, WA.
18. Oaks,W.,Thompson, M., Integration of Service Learning into a Freshman Engineering Course, 2011 ASEE
19. Tsang, E., Haneghan, J. V., Jonshon, B. Newman, E. J. Eck, S. V. A Report on Service- Learning and Engineering Design: Service- Learning's Effect on Students Learning Engineering Design in "Introduction to Mechanical Engineering, International Journal Eng. Education, Vol 17, No 1. 30-39, 2001
20. Saterbak, A. Embree, M. , Oden, M. ,Client-Based Projects in Freshman Design, 2012 ASEE
21. ZarskeM.S., Reamon, D. T. Knight, D. Altruistic Engineering Projects; Do project- Based Service-Learning Designs Impact attitudes in first year engineering students?. ASEE 2011
22. Dimitriu,D. G., et al, A Service Learning Project for a Freshman Engineering Course, ASEE 2011
23. Ghosn, B., Volz, T., Using Project Based, Experiential, and Service Learning in a Freshman Writing Intensive Seminar for Building Design and Technical Writing Skills, June 2015, ASEE, Seattle, WA
24. Lund, L., Bundy, D. What Makes a Successful Service Learning Project for Freshman Engineers?, ASEE 2007
25. http://enablingthefuture.org/