

Engaging Engineering Students in Research from Early Stage of Their Student Career

Binod Tiwari, Ph.D., P.E.

Associate Professor and Acting Chair

Civil and Environmental Engineering Department

California State University, Fullerton

Abstract

Engineering education in the USA has significantly been controlled by the accreditation agency. As a result, classroom education is paid much more attention compared to the hands-on or research activities. In this study, a select group of engineering students were involved in faculty-student collaborative research activities in different stages of their academic standings and their progresses were monitored. The study result shows that students can improve their academic performance significantly after being involved in faculty-student research activities. Moreover, students, involved in research, showed more leadership skill as well as advancement to graduate studies.

Introduction

Undergraduate level engineering courses in US are mainly controlled by the accreditation criteria such as the one set by the ABET (ABET, 2013)¹. The number of semester units that the students have to take to graduate bachelor's degree in engineering mainly ranges from approximately 120 to 140 units depending on the program's requirement for math, science and engineering courses as well as the general education courses. Time taken by a student to graduate also depends on the performance of students in various levels of their studies. For example, if a student fails in lower level math, science and engineering courses, he/she cannot take upper level courses that require to have passing grades in those lower level courses. Therefore, average graduation year of 6 years in some engineering programs is not surprising. Moreover, due to monotonous nature of some theoretical math and science courses, students sometimes feel lost from the beginning of their college career. Although they understand the practical application of those science and math courses when they take engineering courses and perform well in their engineering courses, many students struggle in the lower level math and science courses. One way to motivate and engage these students is to provide them opportunities of engineering research activities so that they can correlate the theory based classes with respective practical implications.

With the Fall 2012 undergraduate enrollment of 32,328, California State University Fullerton is the largest university in the California State University system in terms of student enrollment. Out of 32,328 undergraduate students, students enrolled in engineering and computer science major were only 6.2% (CSUF, 2012)². Likewise, out of 5,349 enrolled post-bachelor degree students, 12.8% were in engineering and computer science majors. Although the graduation rate of the entire university is 64%, the graduation rate of the engineering and computer science students is only 40%. These statistics shows that the number of students enrollment in engineering majors is significantly low compared to the other majors. In addition, the graduation

rate of the engineering students is much lower than the students in other majors. This could be attributed to the high dropout rate in the freshman and sophomore year, where the students are taking math and science courses. Involving students in hands-on experience could be helpful in increasing the retention rate. If the lower classmates (freshman and sophomore level) are paired with the upper classmates (junior and senior level) and graduate students in research, the students can get benefit of being involved in research as well as the mentorship. Moreover, getting opportunities for collecting and analyzing data as well as presenting the research results in different academic avenues provide the students confidence in understanding their regular classes. On the contrary, being involved in such extra-curricular activities and spending several hours in research may affect adversely in their regular classroom performance. To evaluate whether it is beneficial for students to be involved in research from their early stage of undergraduate studies, 61 students were involved in various research projects in collaboration with the author. Students were chosen from different levels of their undergraduate level studies, ranging from sophomore to senior, and GPAs ranging from 2.5 through 3.9. To increase diversity, priority was given to have students from different ethnic backgrounds as well as gender. Parameters chosen to assess the success of the program were - GPA, awards and scholarships, conference presentation, publication, and progress to graduate level studies. Only the data pertinent to undergraduate students are considered in this study, although graduate students were also involved in this study.

Background of Selected Students

Out of 61 students chosen for this study, percentage of sophomore, junior and senior level students were 5, 36, and 59, respectively. 35% of those students were chosen from the students with Hispanic background. Likewise, 21% of those students were female.

Nature of the Research Projects

Students were involved in 12 different research projects. The number of students involved in those projects ranged from 2 to 5, depending on the nature of the project. Moreover, majority of the research projects involved students from all three levels i.e. sophomore, junior and senior. In addition to this, there were two national level competitions that the students participated every year. The pilot study started from Summer 2007 and ended in Fall 2012. Majority of those research projects were fully or partially funded. In terms of student involvement, students involved in their first year were involved either through volunteer interest or for academic credit, whereas the students involved for multiple years were supported through the research assistantship funded by the author's grant projects.

Results of the Study

The effectiveness of the study was evaluated with different criteria, explained below.

Class Grades

Based on the study, the performance of students in terms of GPA increased consistently for the students in all levels. The sophomore level students could raise their GPA by 0.07 (at the scale of

4.0), whereas the junior and senior could raise their GPA by 0.05 and 0.04, respectively. Average GPA those students, selected from each level, were higher than 3.0 at graduation.

Written and Oral Communication Skills

Improvement in the written and oral communication skills were evaluated based on the number of presentations made by the students in various local as well as national/international level conferences and co-authorship in various journal articles as well as conference proceedings. Students involved from sophomore level could make 13 conference presentations, whereas the students involved in junior and senior level could make 33 and 22 presentations, respectively. The students involved in sophomore level, junior level a senior level could co-author 17, 15, and 8 articles, respectively, in various peer reviewed avenues. It should be noted here that out of 55 peer-reviewed publications that the author co-authored in this study period, 45% were co-authored with undergraduate students involved in the study, whereas 9% and 11% of those publications were coauthored with graduate students and a group of graduate and undergraduate students, respectively. All of those undergraduate students were involved in this study.

Scholarships and Grants

One among the indirect benefits of being involved in research and having publication is being able to receive various scholarships and grants. Students having publication, presentation and leadership skill are evaluated highly while reviewing the applications for grants/scholarships. Students involved in their sophomore level received 2 small scholarships (<\$1,000), 6 moderate level scholarships (\$1,000-\$5,000), and 3 major level scholarship (>\$5,000). Likewise, students involved in their junior year received 4 small, 8 moderate, and 8 major level scholarships. The students involved in their senior year were also able to receive 4 moderate and 1 major level scholarships. Three of these students received national level scholarships such as the Eisenhower Transportation Fellowship and the National Science Foundation Graduate Research Fellowship (NSFGRF) with the amount higher than \$10,000, including a \$121,000 NSFGRF. Those students were role models for the junior students.

Involvement in National and Local Level Student Competitions

Students involved in the research were also involved in various national and local level student research/project competitions organized by the national societies such as the American Society of Civil Engineers (ASCE). These were volunteer activities, enthusiastically chosen by the students. Through these competitions, students got opportunities to work in a group, design and implement some engineering projects, in addition to interacting with students and professional nation-wide. These activities helped those students in developing the leadership skills. Students involved in the sophomore level participated in 2 regional and 7 national level professional competitions. Likewise, students involved in their junior year participated in 4 regional and 7 national competitions, whereas the students who joined in their senior year participated in 7 regional competitions only. The travels of those students were supported by the grants provided by the sponsoring organizations such as ASCE and the university resources.

Post-graduation Path

The post-graduation career paths were tracked for all of these students. Record shows that the students chose two major career paths – engineering practice or graduate studies, or both. Some students joined graduate schools while working in the professional field, whereas some students moved further to PhD level studies. Among those who joined in the sophomore year, 1 student enrolled into graduate study in the same field to PhD level, and 2 joined professional practice. However, both of those students enrolled and finished their master's degree while working. Among the students who started research in their junior year, 11 joined professional field as engineers, 6 pursued graduate study, and 5 completed their master's degree while working as professional engineers. Out of those students who joined research in their senior year, 18 joined the professional practice, 4 pursued graduate study, whereas 14 completed their master's degree in civil engineering while working as practicing civil engineers.

Summary and Conclusion

In past 5 years, sixty one students having different academic and ethnic background were selected and involved in various stages of faculty-student collaborative research activities. The progress of students shows that the students involved in research from the early stages of their college years, especially from the sophomore or junior level, could improve their academic performance significantly, engage into various national and regional competitions, acquire various fellowships/scholarships and have academic publications. These achievements motivated those students to perform well in their professional field, as well as moving forward to graduate level studies.

References

1. ABET (2013). [Http://www.abet.org/](http://www.abet.org/)
2. CSUF (2012). Office of Analytical studies and Research. Census data 2012.