Improving Student Success and Retention Rates in Engineering: One Year after Implementation

Nova A. G. Schauss, Steffen Peuker
nova.schauss@oregonstate.edu, speuker@calpoly.edu

Abstract - **To strengthen the commitment of first-year engineering students and improve retention rates, an innovative approach has been developed linking student development focused first-year courses and a project called "Design Your Process of Becoming a World-Class Engineering Student." Set within developmental first-year courses, the project challenges students to design their individually tailored learning process to have a significant impact on their academic success by improving the students' skills, confidence and motivation to succeed in engineering.**

The approach was implemented at Oregon State University (OSU) as well as the University of Alaska Anchorage (UAA).

OSU piloted one section during Fall 2013 of ENGR 199 with students (N=23) who had an average cumulative GPA of 3.04 after Fall 2013 term, compared to the average of a comparator control group of 2.48 who did not complete the course. In regard to academic standing, 88.2% of students who completed ENGR 199 were in Good Standing (2.0+ term GPA) with the University after Fall term, compared to 70.6% of the comparator control group who did not complete the course.

At UAA, the students (N=151) who took ENGR A151 in either Fall 2012 or Spring 2013 had an average cumulative GPA of 3.00 at the end of Spring 2013, compared to the average cumulative GPA of 2.51 of the students (N=112) who did not take the course. The retention rate of students who took ENGR A151 was 87.4% compared to 79.5% who did not take ENGR A151.

Based on the first year implementation results from OSU and UAA, the approach of linking a student development course with the "Design Your Process of Becoming a World-Class Engineering Student" project, is an effective method to improve engineering student success and retention rates, because it can be implemented virtually anywhere with minimal cost and change of curriculum.

Index Terms - student success, retention, design project, first-year students

INTRODUCTION

There is a current concern about the growing need for more engineers in the U.S. Therefore, both first-year engineering student retention and time to graduation need to be improved. A national study conducted by Michelle J. Johnson and Sheri D. Sheppard [1] shows that over 30% of first-year engineering students do not finish with a degree. Even more concerning is that only 8% of all students enrolling in a 4 year college chose an engineering program. This demonstrates the need for increased focus on first-year engineering education through strengthening a student's commitment and efficiency to graduate with an engineering degree.

A recent study investigated why students stay in engineering and found that increasing the first-year student's academic confidence helps the student adjust to the rigorous engineering curriculum [2]. In another study, students ranked "drive and motivation" as one of the top influences to believing they could succeed [3]. Successful minority retention programs have focused on community building, academic success skills, personal development, professional development, and orientation in a first-year introductory engineering course [4]. The 2004 ACT policy report on The Role of Academic and Non-Academic Factors in Improving College Retention identified the following factors as the strongest in predicting college retention or performance: academic-related skills, academic self-confidence, and academic goals [5].

All the aforementioned proven factors for student success are addressed by an innovative approach linking student development focused first-year courses and a project called "Design Your Process of Becoming a World-Class Engineering Student". Last year the approach was implemented at two institutions, Oregon State University and the University of Alaska Anchorage, and the results regarding the impact of this approach one year after implementation are presented.

APPROACH

A new innovative approach has been developed to increase engineering student success and retention by linking student development focused first-year courses and a project called "Design Your Process of Becoming a World-Class Engineering Student".

The concept of "student development" can be summarized as facilitating new students' growth, instilling positive change, and developing strategies that will enhance their success in the study of engineering. The first-year courses at the University of Alaska and Oregon State University were developed after the model presented by Raymond B. Landis who outlines five cornerstone objectives which will benefit students: 1) improve their peer environment; 2) teach them essential academic success skills; 3) aid them in their personal development; 4) enhance their professional development; and 5) orient them to the engineering college and the university [6]. A comprehensive instructor's guide has been published by Raymond B. Landis to facilitate the implementation of student development focused first-year courses [7].

The project, "Design your Process for Becoming a World-Class Engineering Student", builds upon the student development objectives introduced in the courses. Students are asked to design their own individual process to be successful in graduating with an engineering degree and write a project report at the end of the course.

The project challenges students to evaluate themselves against a "world-class" engineering student based on the following objectives:

1. Setting goal(s), e.g. which major to pursue, graduating with an engineering degree, etc.
2. Developing a strong commitment to the goal of graduating in engineering, setting-up a graduation plan
3. Being prepared to deal with inevitable adversity
4. Managing various aspects of personal life including interactions with family and friends, personal finances, outside work, and commuting
5. Changing attitudes to be successful in math/science/engineering coursework
6. Understanding teaching styles and learning styles and how to make the teaching/learning process work for you
7. Understanding and practicing the concept of "metacognition" to improve the individual learning process and making positive changes based on the feedback
8. Outlining changes in behaviors to be successful in math/science/engineering coursework
9. Managing time and tasks
10. Understanding the principles of teamwork and leadership and developing skills to be both an effective team member and also an effective team leader
11. Participation in co-curricular activities
12. Understanding and respecting differences in learning styles and personality types and in ethnicity and gender
13. Engaging in good health and wellness practices including management of stress
14. Developing a high sense of personal and professional integrity and ethical behavior
15. Becoming effective at getting the most out of the educational system by utilizing campus resources
16. Adding objectives you perceive are important for your success

To help guide students in their evaluation they are asked to implement a three step process:

a. Where a "world-class" engineering student would want to be on each item
b. Where you are currently on each item
c. What you need to do to move from where you are to where you would need to be to become a "world-class" engineering student

By analyzing parts a. and b. students are able to answer c. which outlines their path to success for each individual objective.

A general handout of "Design your Process for Becoming a World-Class Engineering Student" has been published in Appendix A of "Studying Engineering: A Road Map to a Rewarding Career" [8].

The advantages of linking a student development course and the "Design your Process for Becoming a World-Class Engineering Student" project are:

- Students develop individual accountability for their success
- Students develop a well-defined view of what they need to change in their academic as well as personal life to be successful
- Setting the goal of graduating with an engineering degree and developing a plan to achieve the goal will result in more efficient students, potentially reducing the time to graduation, and reduce the number of students who "drift aimlessly" through a curriculum
- Students will perform better in all courses
- The skills students develop to be an effective engineering students are the same skills they need in their later career
- Learning to apply general student development topics from the course to their personal development

IMPLEMENTATION

The following section outlines how the approach was implemented at two universities, Oregon State University and the University of Alaska Anchorage.

Implementation at Oregon State University

During the Summer of 2013, the OSU College of Engineering committed to the design of a new course, ENGR 199, Foundations for Engineering Success, targeted at first-year pre-engineering students who entered with math proficiency levels below College Algebra. Students entering at this level of math proficiency are unable to complete an engineering degree in the standard 4 year timeline. Consequently, these students are at risk for both retention and persistence within the College. ENGR 199 was designed as an intervention strategy to address this challenge.

The course was both designed and taught by the College's Student Success Specialist, and followed the curriculum model outlined in the Approach section. The syllabus for ENGR 199 can be found here [9]. Enrollment in ENGR 199 was dependent on College of Engineering advisors recommending a student for the course based on his/her math placement score during OSU's new student orientation and registration program. Eligible students were not mandated to take the course; however advisors actively and intentionally recommended the course for eligible students. The course was only offered during Fall term of the academic year, as it is intended for first-year first-term students.

As a pilot, course enrollment was limited to 25 students in one section, with students representing all engineering majors. As a 2 credit course, students experienced 60 total contact hours throughout the term, achieved through twice weekly 50 minute class sessions. Classes were structured as discussion based, with regular opportunities for teamwork and active student-directed learning. Students earned a letter grade (A-F), and the grade impacted a student's term and cumulative GPA. Project grades accounted for 40% of a student's final course grade, and supplemented a final exam.

Implementation at University of Alaska Anchorage

The first-year course, ENGR A151, at UAA is a 1 credit introduction to engineering course required for several engineering majors. The course is taught once a week, lasting 50 minutes each in duration over a 14 week term. The breakdown of majors given in Figure 1 is based on a survey provided to students who took ENGR A151 in the Fall 2012 (N=79) and Spring 2013 (N=77)—students are not required to declare a major in their first-year. The survey asked students to indicate which major they are enrolled in or most likely to graduate in. The response rate to the survey was 87% (N=136).

The course was taught in the Fall 2012 and Spring 2013 following the student development model as outlined by Raymond B. Landis [6,7]. The course combined lectures with regular opportunities for teamwork and active student-directed learning. Weekly homework assignments as well as multiple choice exams were implemented. The syllabus for ENGR A151 can be found here [10]. The project "Design your Process for Becoming a World-Class Engineering Student" was given in place of a final exam and accounted for 30% of the student's grade. The project handout as provided to the students can be found here [11].

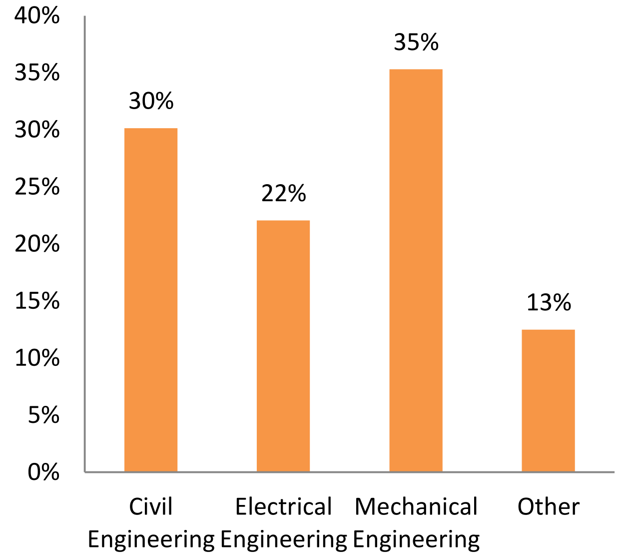

FIGURE 1
BREAKDOWN OF STUDENTS BY MAJORS WHO TOOK ENGR A151

RESULTS

Oregon State University

At the conclusion of Fall term, the OSU College of Engineering Student Success Specialist partnered with the Office of Assessment to identify statistical differences between students who completed ENGR 199 and a comparator control group. The ENGR 199 cohort and control group were comparable on measures of math placement exam score, SAT math score, first term math course, engineering major, first term of attendance, and admission type (full-time with 12+ registered credits). ENGR 199 cohort students with either missing or miscoded data (math placement exam score, SAT math score or admission type) were removed from the data set. While 23 students completed ENGR 199, 6 were removed from the data analysis due to missing records of the relevant variables. Therefore, an N of 17 is used for data analysis.

College leadership was most interested in two sets of data analyses related to the ENGR 199 cohort and comparator control group: 1) Cumulative GPA after Fall term, and 2) Percentage of students in Good Academic Standing (2.0+ term GPA) with the University after Fall term. These areas of data assessment were identified as being most directly related to retention and persistence, both within the College of Engineering specifically and the University as a whole.

Table I summarizes the assessment results and Figures 2 and 3 provide a graphical depiction. The average cumulative GPA of the ENGR 199 students was 3.04 after Fall 2013 term, compared to the average of a comparator control group (N=17) of 2.48 who did not complete the course. Using a t-test, it was determined that ENGR 199 does not have a statistically negative impact on student achievement as measured by GPA. A larger sample size is necessary to ascertain further statistically significant differences between the two populations. In regard to academic standing, 88.2% of students who completed ENGR 199 were in Good Standing (2.0+ term GPA) with the University after Fall term, compared to 70.6% of the comparator control group who did not complete the course. While a Fisher's Exact Test would be an appropriate statistical methodology for analysis of academic standing, the small sample size resulted in statistically insignificant results for this particular statistical analysis.

TABLE I
RESULTS FROM OREGON STATE UNIVERSITY

	N=	Cumulative GPA after Fall	% Students in Good Standing after Fall
ENGR 199	17	3.04	88.20%
No ENGR 199	17	2.48	70.60%

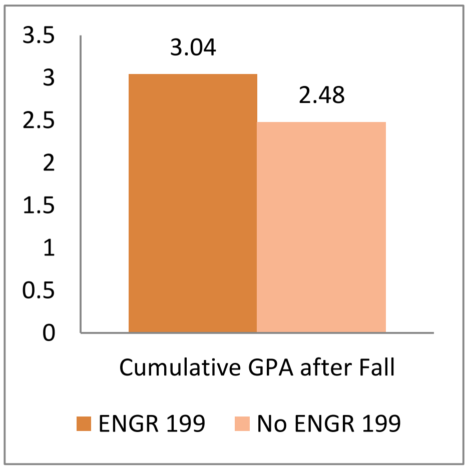

FIGURE 2
CUMULATIVE GPA COMPARISON ONE TERM AFTER IMPLEMENTATION

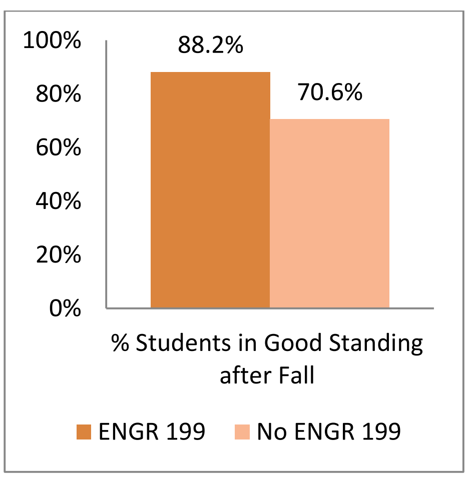

FIGURE 3
STUDENTS IN GOOD STANDING ONE TERM AFTER IMPLEMENTATION

University of Alaska Anchorage

The results from UAA one year after implementation of the approach linking ENGR A151 with the "Design your Process for Becoming a World-Class Engineering Student" project are very similar to the results from OSU.

TABLE II
RESULTS FROM UNIVERSITY OF ALASKA ANCHORAGE

	N=	Cumulative GPA after Fall	Retention after Fall 2013
ENGR A151	151	3.00	87.4%
No ENGR A151	112	2.51	79.5%

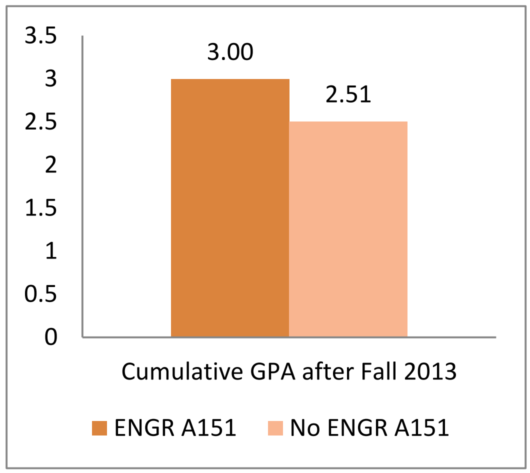

FIGURE 4
CUMULATIVE GPA COMPARISON ONE YEAR AFTER IMPLEMENTATION

As Figure 4 shows, the cumulative GPA of the students (N=151) who took ENGR A151 in the Fall 2012 or Spring 2013 semester is 3.00 compared to 2.51 for the students who did not take ENGR A151. It should be noted that ENGR A151 is not a required course for all majors in the College of Engineering at UAA which explains the number of students (N=112) who started as freshmen in Fall 2012 or Spring 2013 but did not take ENGR A151.

Figure 5 shows the retention rate of students who took ENGR A151 in the Fall 2012 or Spring 2013 semester and are still enrolled in engineering courses by the end of the Fall 2013 semester.

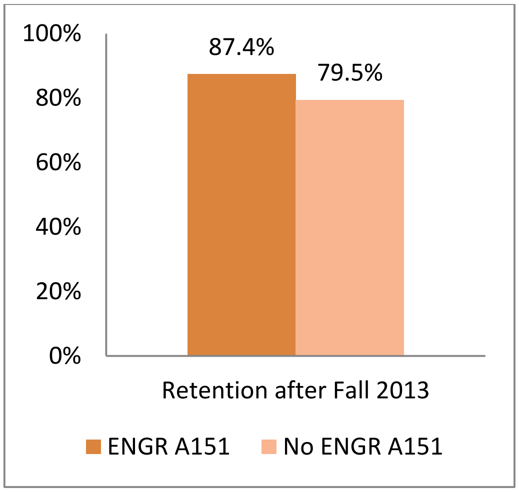

FIGURE 5
RETENTION COMPARISON

Although these results are snap-shots, and future tracking of the students who took ENGR A151 in the Fall 2012 or Spring 2013 semester is on-going, the results do indicate an improvement in both GPA and retention.

To assess how students perceived the project a survey was provided to the students who took ENGR A151 in the Spring 2013 semester and N=70 students replied to the survey.

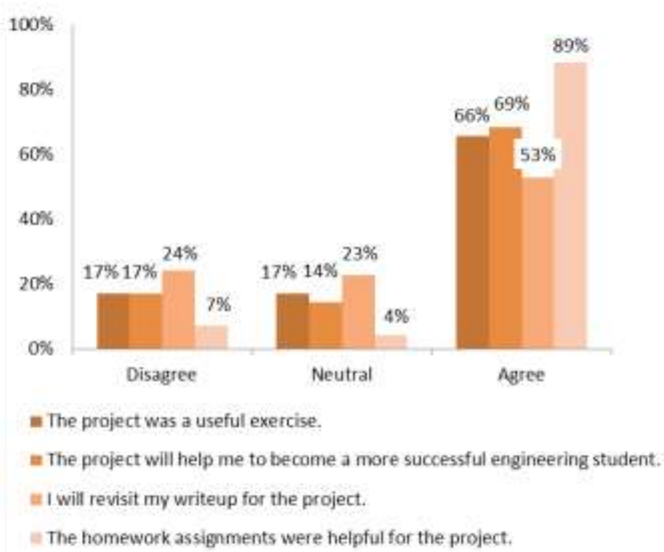

FIGURE 6
RESULTS OF SURVEY GIVEN TO ENGR A151 STUDENTS AFTER SPRING 2013 TERM

As Figure 6 shows, two thirds of the students agreed that the project was a useful exercise and that it will help them to become a more successful engineering student. About half the students agreed that they will revisit their project report in the future. Assigning homework related to the project throughout the semester resonated very well with the students, and 89% agreed that the homework was helpful for them. In terms of implementation, linking lecture and project through homework assignments is one of the key elements for successful implementation of the approach.

CONCLUSIONS

Initial results of the OSU ENGR 199 pilot were quite encouraging, and suggest that the “Design Your Process of Becoming a World-Class Engineering Student” project, intentionally located within a student development course, does have a positive impact on student retention for a marginalized population—increasing from 70.6% to 88.2%. Though the sample population was small, the quality of course design and implementation was highly thoughtful, and allowed for a manageable pilot with regard to instructor time and financial cost. The gradual implementation of curriculum redesign created an opportunity to gather and analyze data with a small population, identify the strengths and limitations of the course structure, and systematically consider strategies to expand the course to a larger student population. This process functioned well within an administrative organization that requires data to inform curriculum changes. The results from the pilot year created administrative support to expand the number of ENGR 199 sections to 3 for Fall 2014. The course design will be identical to the pilot year, and allow for 75 students to enroll in the course. This will create a data comparison with the pilot year, and utilize a greater sample size. Data from the second year of implementation will then be assessed and used to determine the course size and capacity of ENGR 199 for Fall 2015. This will also help inform potential resource needs, including additional staff resources and curriculum training for new course instructors.

The initial results from UAA showed that the approach of linking a student development course—ENGR A151—and the “Design Your Process of Becoming a World-Class Engineering Student” project had a positive impact on first-year engineering student retention—an increase of 7.9%—and GPA—an increase of 0.49—one year after implementation. Although the student populations between ENGR 199 at OSU and ENGR A151 at UAA were different, both in terms of sample size and student standing, the results are remarkably similar, i.e. GPA increase of 0.56 for OSU compared to 0.49 for UAA cohorts. The implementation at both OSU and UAA was accomplished cost neutral; the only investment was the time by the faculty to re-design the course content. It should be pointed out the implementation at UAA was accomplished in a 1 credit course and therefore the presented approach could be implemented as part of an existing 3 credit course with changing only a third of the course content.

Based on the first year implementation results from OSU and UAA, the approach of linking a student development course with the “Design Your Process of Becoming a World-Class Engineering Student” project is a strategic method to improve engineering student success and retention rates, because it can be implemented virtually anywhere with minimal cost and change of curriculum. In addition, the approach seems to be beneficial for both students' at-risk as well as general admitted first-year engineering students.

The OSU ENGR 199 pilot cohort and the UAA ENGR A151 cohorts will be tracked over time, and additional data collection will occur related to cumulative GPA, academic standing, retention within engineering, and retention in the University. It remains to be seen if the positive impact of the approach of linking student development courses and the "Design Your Process of Becoming a World-Class Engineering Student" significantly benefits a student beyond the first year.

REFERENCES

[1] Veenstra, Cindy P., Dey, Eric L., Herrin, Gary D., "A Model for Freshman Engineering Retention", AEE, Volume 1, Issue 3, Winter 2009

[2] Meyers, Kerry L., Silliman, Stephen, E., Gedde, Natalie, L., Ohland, Matthew, W., "A comparison of engineering students' reflections on their first year experiences.", J. Engineering Education, April 2010

[3] Hutchison, Mica A., Follman, Deborah K., Sumpter, Melissa, Bodner, George M., "Factors influencing the self-efficacy beliefs of first year engineering students", J. Engineering Education, January 2006

[4] Landis, R. B., "Student Development: An Alternative to 'Sink or Swim'", Proceedings of 1994 ASEE Annual Conference, June 1994

[5] Lotkowski, Veronica A., et al. "The Role of Academic and Non-Academic Factors in Improving College Retention", ACT Policy Report, www.act.org/research/policy/index.html

[6] Landis, R.B., "Improving Student Success Through a Model 'Introduction to Engineering' Course," Proceedings of 1992 ASEE Annual Conference, Toledo, Ohio, June, 1992.

[7] Landis, R.B., "Instructor's Guide: Enhancing Student Success through a Model Introduction to Engineering Course", http://discovery-press.com/

[8] Landis, R.B., "Studying Engineering: A Road Map to a Rewarding Career", Fourth edition, Discovery Press, Los Angeles, California, ISBN 978-0-9793487-4-7

[9] http://www.discovery-press.com/discovery-press/studyengr/Syllabi/ENGR199OSU.pdf

[10] http://www.discovery-press.com/discovery-press/studyengr/Syllabi/ENGRA151Alaska.pdf

[11] http://www.discovery-press.com/discovery-press/studyengr/Projects/P1.pdf

AUTHOR INFORMATION

Nova A. G. Schauss, Student Success Specialist, College of Engineering, Oregon State University, Corvallis, nova.schauss@oregonstate.edu

Steffen Peuker, James L. Bartlett Jr. Endowed Professor, Mechanical Engineering, California Polytechnic State University, San Luis Obispo, speuker@calpoly.edu