122nd ASEE Annual Conference & Exposition
June 14 - 17, 2015
Seattle, WA
Making Value for Society
Paper ID #11270

Improving Student Success and Retention Rates in Engineering: An Innovative Approach for First-Year Courses

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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". The project is set within first-year engineering orientation courses that pair academic success strategies with engineering college knowledge. Through the project students are challenged 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 is currently implemented in over 30 institutions nationwide**Error! Reference source not found.**. The results from two four year institutions— Oregon State University and University of Alaska Anchorage—one year after initial implementation are presented.

Although the sample size at the Oregon State University was small (N=17), the results are powerful in relation to retention within the university. Of the students who completed the course (N=17) 94% were retained at the university one year later, compared to 53% of the control group, resulting in a statistically significant difference ($p<0.01$). The difference in cumulative GPA after one year among students who took the course (GPA of 2.82) compared to the control group (GPA of 2.63) did show an increase; however, it did not prove to be statistically significant.

Initial results from the University of Alaska Anchorage showed that the approach of linking a student development course, and the "Design Your Process of Becoming a World-Class Engineering Student" project had a positive impact on first-year engineering student retention and performance. The cumulative GPA of the students who took the course (N=151) was 3.00 after the first year, compared to 2.51 (N=112) of the control group, showing a statically significant difference ($p<0.001$). The retention rate after one year was not found to be statistically significant at the five percent level ($p=0.08$), however, an increase from 79.5% to 87.4% in the first-year retention rate was observed.

The implementation at both institutions was accomplished cost neutral; the only investment was the time by the faculty to re-design the course content. Based on the first-year implementation results from both institutions, 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.

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[2] 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 four year college chose an engineering program. As Veenstra et al. conclude from considering more recent data, "…there is an urgent need for more graduating engineers. Yet, the engineering colleges are challenged with retaining engineering students. Less than 57% of the students, who begin engineering college, complete their engineering program."[3] 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[4]. In another study, students ranked "drive and motivation" as one of the top influences to believing they could succeed[5]. Successful retention programs aimed at underrepresented students have focused on community building, academic success skills, personal development, professional development, and orientation in a first-year introductory engineering course[6]. 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[7].

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". The approach was implemented at Oregon State University and the University of Alaska Anchorage in the 2013-2014 academic year. The results regarding the impact of this approach one year after implementation, and discussion of ongoing assessment, are presented.

Approach

The concept of "student development" can be summarized as facilitating new students' growth, instilling positive change, and developing strategies that will enhance their success. For further, general information about "student development", see N. J. Evans et al. who conclude that "student development is almost universally viewed as a good thing" [8].

A new innovative approach has been developed to increase engineering student success and retention by linking student development focused first-year engineering courses and a project called "Design Your Process of Becoming a World-Class Engineering Student". It is important to emphasize the "engineering" student development focused first-year courses to distinguish from general student development focused courses. The first-year engineering courses at the University of Alaska Anchorage and Oregon State University were developed after the model presented by Raymond B. Landis who outlines five cornerstone objectives which will benefit engineering students: 1) improve their peer environment; 2) teach them essential academic survival skills; 3) aid them in their personal development; 4) enhance their professional development; and 5) orient them to the engineering college and the university[9]. A comprehensive instructor's guide has been published by Raymond B. Landis to facilitate the implementation of student development focused first-year engineering courses[10].

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. 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"[11]. The project challenges students to evaluate themselves against a benchmark student—referred to as 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 plan to graduation
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. Participating 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 designing their process 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 part a. and b. students are able to answer c. which guides them to develop their process to succeed at each individual objective.

The linking of an engineering student development course and the "Design your Process for Becoming a World-Class Engineering Student" project is key, so that students recognize what a "world class" engineering student would do to be successful. This allows students to develop their individualized process to become a successful engineering student and the project provides a written document which the students can revisit throughout their career as an engineering student. The benefits of this approach can be summarized as follows:

- Individual accountability for success as an engineering student
- 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 plan

The focus of the presented approach is to improve student success and retention rates and assessment data is presented in the Results section. Although data is not yet available, it would not be surprising if this approach shows improvement in the time to graduation for engineering students as well because of the aforementioned benefits.

A support website has been developed to help other instructors with the implementation of the project[1]. The website provides class room material, sample student project reports, assessment/research materials and more.

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 Oregon State University 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 four 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 Coordinator, and followed the curriculum model outlined in the Approach section. The syllabus for ENGR 199 is posted at the support website[1]. 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 Oregon State University'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 the University of Alaska Anchorage

The first-year course, ENGR A151, at the University of Alaska Anchorage 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 Fall 2012 and Spring 2013 following the student development model as outlined by Raymond B. Landis[9,10]. 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. Assignments as well as the syllabus for ENGR A151 are posted at the support website[1]. 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 is posted at the support website[1].

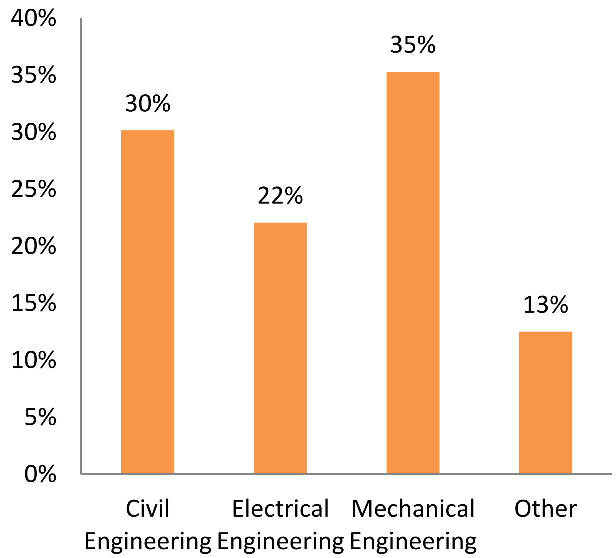

Figure 1 Breakdown of Students by Majors who took ENGR A151 in AY 2012/2013 - UAA

Results – Oregon State University

At the start of Fall term 2014, the Oregon State University College of Engineering Student Success Coordinator partnered with the Office of Assessment to identify statistical differences between students who completed ENGR 199 and a comparator control group one year later. 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 three sets of data analyses related to the ENGR 199 cohort and comparator control group: 1) Cumulative GPA, 2) Retention of students within the institution regardless of major, and 3) Retention of students within engineering. Data analysis for all three data sets occurred in Fall of 2014 to align with institutional practices of measuring retention data once yearly in the fourth week of Fall term.

Figure 2 depicts the percent of students retained at Oregon State University, and shows the measurably positive impact of course enrollment for this student population with 94% of those who completed the course retained at the institution one year later compared to 53% of the comparator cohort. With a statistically significant difference at the $P<0.01$ level, it appears that completion of ENGR 199 has remarkable benefit to students beyond accumulation of engineering knowledge. The course may have a significant impact on college success as a whole as measured by institutional retention percentages, suggesting that this type of course model has the potential for far reaching benefits for both the College of Engineering and University.

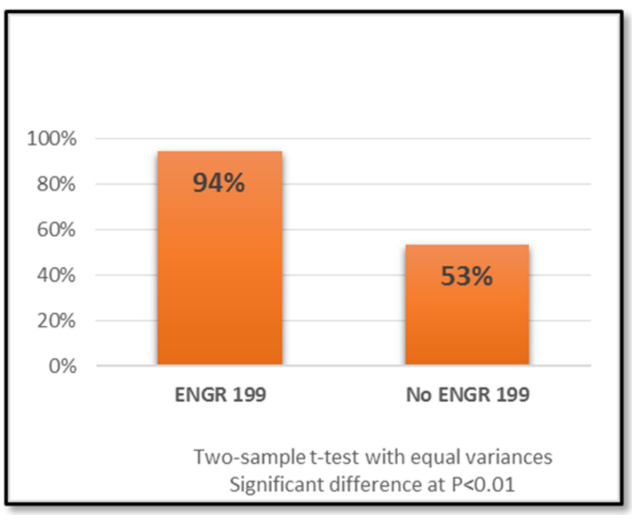

Figure 2 Comparison of Retention - Oregon State University

As seen in Figure 3, the average cumulative GPA of the ENGR 199 students was 2.82 one year after course completion, compared to the average of a comparator control group of 2.63 who did not complete the course. Using a two-sample 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.

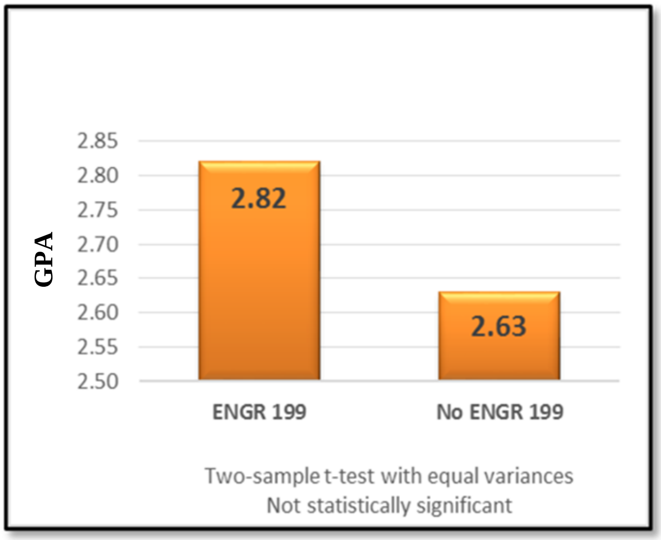

Figure 3 Cumulative GPA Comparison One Year after Implementation - OSU

Assessment of retention within engineering proved to be particularly interesting as seen in Figure 4. The data suggests that enrollment in ENGR 199 does not negatively impact retention within engineering; rather, it assists students who determine that engineering is not an appropriate fit to migrate to a different academic area at Oregon State University instead of leaving the institution entirely. The unique student population enrolled in ENGR 199 may impact this trend; however, more extensive data analysis is needed with a larger sample population to suggest this correlation with any sense of cogency.

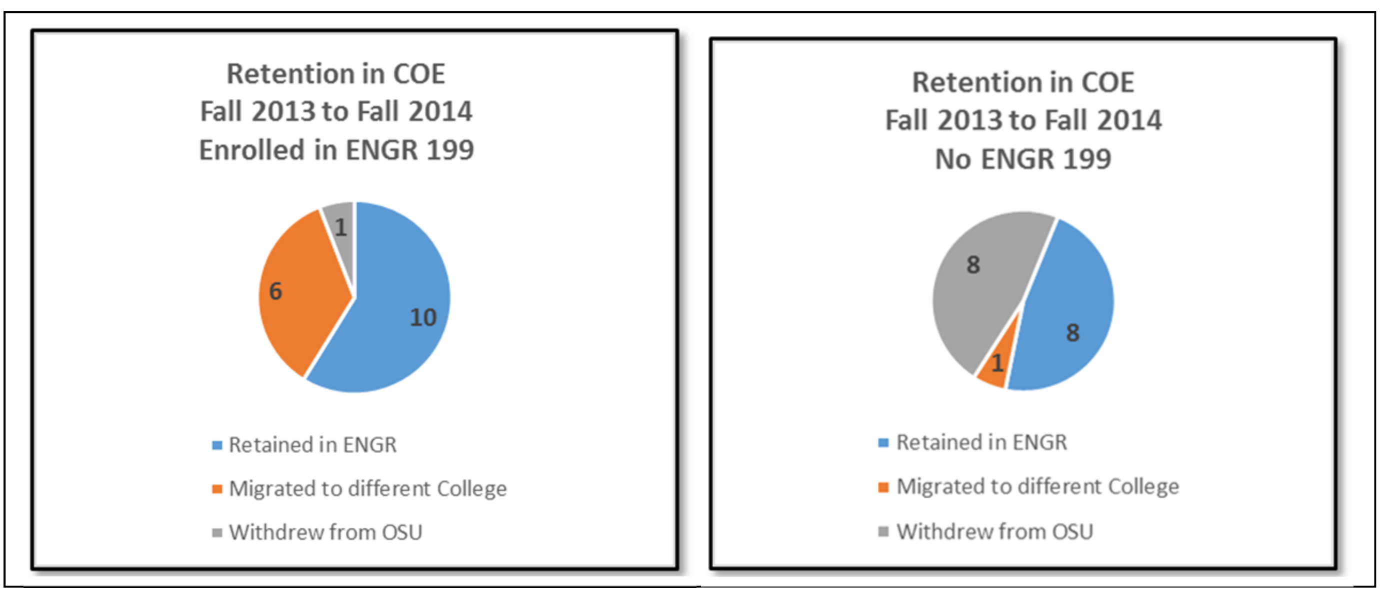

Figure 4 Retention within Engineering One year after Implementation – OSU

Results – University of Alaska Anchorage

The results from the University of Alaska Anchorage one year after implementation of the approach linking ENGR A151 with the "Design your Process for Becoming a World-Class Engineering Student" project show similar trends to those from Oregon State University.

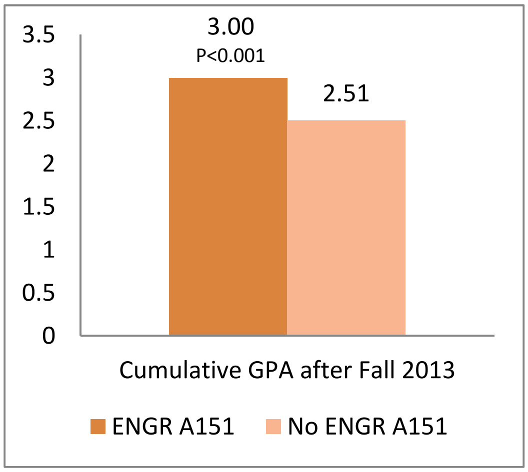

Figure 5 Cumulative GPA Comparison One Year after Implementation - UAA

As Figure 5 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 the University of Alaska Anchorage which explains the number of students (N=112) who started as freshmen in Fall 2012 or Spring 2013 but did not take ENGR A151. The difference in cumulative GPA of the students who took the course compared to the students who did not was found to be statically significant ($P<0.001$).

Figure 6 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 compared to the student cohort who did not take ENGR A151 in their first-year. The retention rate after one year was not found to be statistically significant at the five percent level ($P=0.08$), however, an increase from 79.5% to 87.4% in the first-year retention rate was observed.

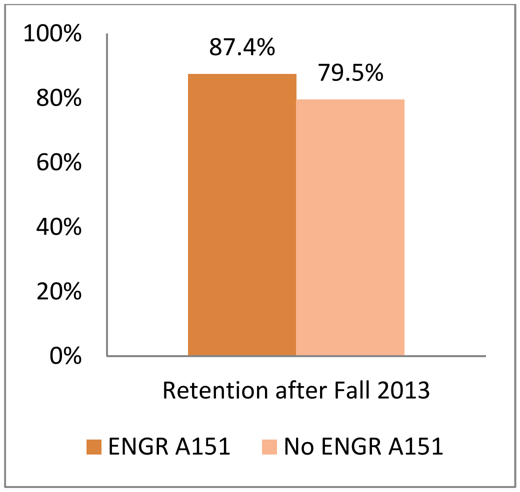

Figure 6 Retention Comparisons - University of Alaska Anchorage

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.

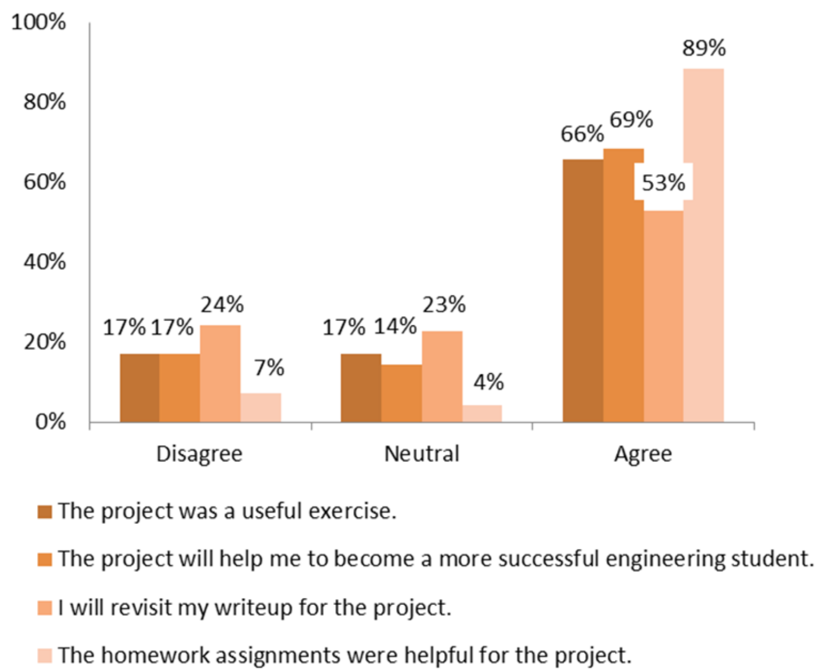

Figure 7 Results of Survey given to ENGR A151 Students after Spring 2013 Term

As Figure 7 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.

Limitations

Data collected at OSU will allow for multiple cohort comparisons as the project will be administered via ENGR 199 for a third time during the 2015-2016 academic year. However, the small sample size of the pilot year remains the only complete data set at this time, as retention and academic performance rates for the second cohort will not be calculated until Fall 2015. In the interim, few statistical calculations can be run with a sample size of 17 and it is therefore yet to be seen if the impressive initial results are comparable to subsequent cohorts. Thus far, the student population exposed to the project at OSU is not representative of the greater first-year population, as it is comprised of students entering with low demonstrated mathematical abilities. Potential generalizability is therefore limited to this specific subset of the first-year student population until the project is expanded to students across the mathematical spectrum.

While the "Design Your Process of Becoming a World-Class Engineering Student" project at UAA included a significant representation of the first-year student population, the project is not institutionalized and therefore future implementation and assessment is decided by the instructors teaching the course. As a result, the encouraging data collected for the 2013-2014 cohort may prove to be the only cohort data set from UAA.

Conclusions

Initial results of the Oregon State University 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—as seen by the 53% vs. 94% retention rate. 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 three for Fall 2014. The course design was identical to the pilot year, and had a total student enrollment of 82 students. 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, anticipated to include 4 sections with a maximum total enrollment capacity of 120 students. This will also help inform potential resource needs, including additional staff resources and curriculum training for new course instructors.

The results from the University of Alaska Anchorage showed that the approach of linking a student development course and the “Design Your Process of Becoming a World-Class Engineering Student” resulted in a statically significant increase in first-year engineering student’s cumulative GPA—0.49 points increase, P<0.001—from 2.51 to 3.00. The retention rate after one year was not found to be statistically significant at the five percent level (p=0.08), however, an increase from 79.5% to 87.4% in the first-year retention rate was observed.

The implementation at both institutions 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 the University of Alaska Anchorage 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 both institutions, 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 shows to be beneficial for both students’ at-risk for academic difficulty as well as general admitted first-year engineering students.

Resources to support instructors in implementing the "Design Your Process of Becoming a World-Class Engineering Student" project/approach are available, including class room material, sample student project reports, assessment/research materials and more[**Error! Reference source not found.**].

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