Student Persistence and Retention in Engineering

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Abstract - The national economic growth significantly depends on a technically skilled workforce that creates new goods and services, and new capital for U.S. competitiveness. Hence, increasing college attainment of science and engineering students is vital to the growing jobs of the economy and to the U.S. economic competitiveness. However, there is a growing concern about the adequacy of a strong, talented, and innovative science and technology workforce that can respond effectively to the challenges and opportunities necessary to maintain United States' technological progress and economic growth. Research has shown that more than half of the students who start out in science or engineering in their first year in college switch to other majors or do not earn a degree. Evidence indicates that first-year undergraduate students are most at-risk of switching to other majors or dropping out of college. A large part of the problem may lie in their performance in the college introductory courses, and the way these courses are traditionally taught. Their performance in the introductory courses tells them that they are not good enough in mathematics and/or science; they are not convinced about the relevance of what they are being taught, and therefore, decide to switch to other majors. The science and engineering curriculum should be designed to emphasize the application of learning to real life and stimulate transfer of learning. It is, therefore, imperative that efforts are made to support the retention of engineering students by address the issues that contribute to their low performance in their first year in college. Intrusive and intentional intervention strategies are needed to address the challenges that would promote their academic success in order to produce sufficient numbers of graduates necessary to meet the projected engineering workforce. This paper discusses strategies for transforming teaching and learning, and increasing students' curiosity and engagement in science and engineering with the objective of improving student persistence and completion.

Index Terms - Degree completion, College attainment, Engineering attrition, Student persistence

INTRODUCTION

A shortage of engineering graduates threatens America's ability in meeting the demand for workers with scientific and technical knowledge and capabilities necessary for economic competitiveness. To ensure that America maintains its role as the world's leading innovator, President Barack Obama's Council on Jobs and Competitiveness has called for strategies to produce 10,000 more engineering graduates annually. However, there is a growing concern about the adequacy of a strong, talented, and innovative engineering workforce that can respond effectively to the challenges and opportunities necessary to maintain United States' technological progress and economic growth. It is believed that the number of students earning engineering degrees will not be able to meet the increasing demand for the engineering workforce necessary for national competitiveness, education policy, innovation, and security [1-2].

Persistence in engineering education requires the ability and commitment to stay the course, from the freshman year through the senior year, and acquire the requisite skills for successfully becoming a member of the engineering profession.

Research has shown that more than half of the students who start out in science or engineering in their first year in college switch to other majors or do not finish college [3]. Many potential engineering graduates enrolled as engineering students as freshmen are lost to attrition by the end of their freshman year.

Factors that contribute to student dropout from engineering programs include inadequate teaching and advising, lack of faculty guidance and academic support, lack of personal encouragement and attention from faculty members, and mismatches between the way engineering is taught and the way students learn [3]. It is essential that institutions provide resources to adequately address these areas of concern, improve student learning, and enhance student retention.

According to Tinto's interactionalist theory [4], persistence is dependent on a student's ability to successfully integrate into the institution academically and socially. The concept of dual socialization holds that the institution and the student share the responsibility for successfully integrating the student into the institution [5]. While the institution has the responsibility to create an environment for successful cultural and social integration, students share the responsibility for incorporating themselves into the institution.

Much of the current research indicates that academic performance (high school GPA and negative experiences in freshmen introductory courses), attitudinal factors (motivation, confidence, commitment to becoming an engineer, a sense of belonging, and social connectedness), academic engagement and advising, and social and family

support are correlates of persistence in engineering education [2].

Figure 1 shows that the number of engineering degrees awarded rose from 59,487 in 2000 to 87,812 in 2013, while enrollment in engineering programs was almost stagnant between 2000 and 2006, and grew steadily from 431,910 in 2007 to 543,836 in 2012, and decreased to 541,705 in 2013; while enrollment in engineering technologies was almost stagnant from 107,165 in 2000 to 110,893 in 2012, and decreased to 70,664 in 2013 [6].

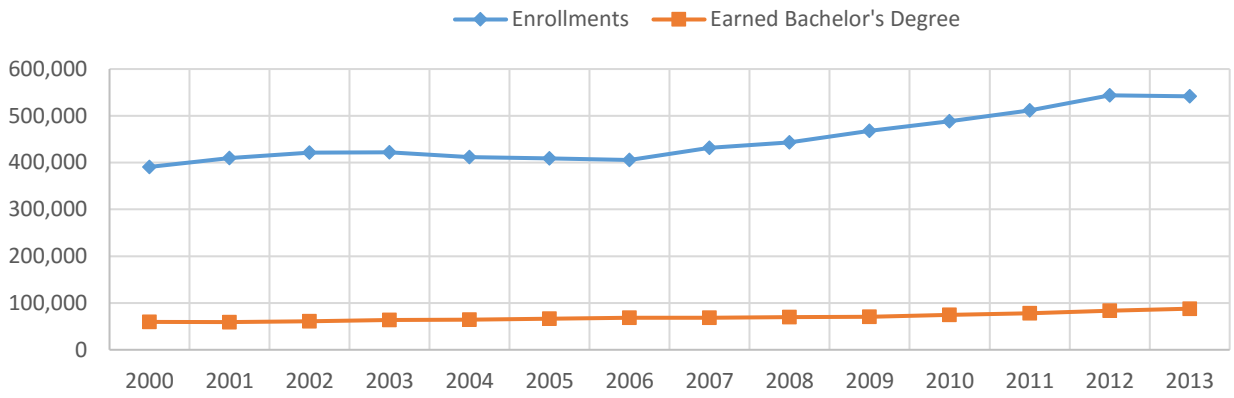

FIGURE 1. ENROLLMENT AND GRADUATION, 2000-2013
SOURCE: *SCIENCE AND ENGINEERING INDICATORS 2016*

As shown in Figure 2, 7.5 percent of students who were enrolled as freshmen in 2007 declared majors in engineering, but 4.7 percent of students who graduated in 2013 earned degrees in engineering [6]. Hence, effective strategies are needed to reduce attrition and increase persistence and graduation rate of engineering students. Factors that contribute to student attrition from engineering include individual variables, such as poor academic performance, feeling unprepared for demands of the engineering program, difficulty fitting into engineering, and change in interest and career goals; and institutional factors, such as disappointment with engineering advising and classroom and academic climate [2, 3, 7]. Other factors include students' inability to develop emotional attachment with the concept of being an engineer. Some studies have suggested that the difficulty that some students encounter in transitioning from high school to college is one of the reasons for engineering attrition. While this might be the case for students who left without obtaining a degree, it might not be applicable to students who switched to other disciplines.

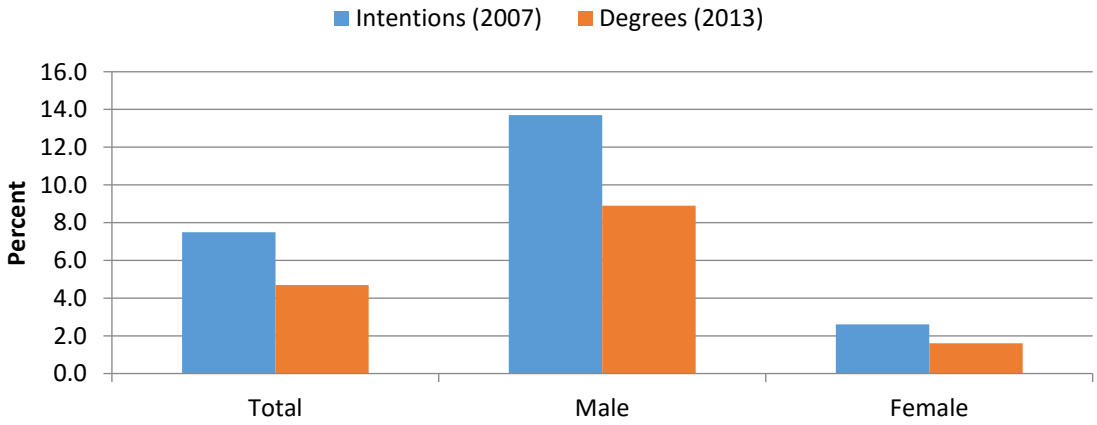

FIGURE 3. ENGINEERING: FRESHMEN INTENTIONS AND DEGREES
NOTE: DEGRESS DO NOT REFLECT THE SAME STUDENT COHORT
SOURCE: *SCIENCE AND ENGINEERING INDICATORS 2016*

This paper discusses interventional strategies for transforming teaching and learning, and increasing students' curiosity and engagement in science and engineering with the objective of increasing persistence, reducing attrition, and earning a degree in engineering.

TRANSFORMING TEACHING AND LEARNING

The greatest barrier to student persistence and completion in engineering occurs between the freshman and sophomore years. Santiago and Hensel [7] studied 527 students who switched from engineering during their first or second year of the engineering program and found that some students leave engineering discipline due to loss of interest in engineering. Geisinger and Raman [3] conducted a review of the literature on students' decision to leave engineering programs. They identified the following six broad factors: classroom and academic climate, grades and conceptual understanding, self-efficacy and self-confidence, high school preparation, interest and career goals, and race and gender. A study conducted by Chen [2] found that about 33 percent of students who declared a STEM major between 2003 and 2009 left STEM fields by spring 2009. These students have the potential to become scientists, engineers, and innovators. Burtner [8] reported that students' confidence in college-level math/science ability and the belief that an engineering degree enhances career security influenced their persistence in engineering.

The authors conducted a survey of students at an HBCU in spring 2016 to identify causes that impact students' decisions to leave engineering programs. Over 66 percent of the respondents who changed their majors indicated that they did so because they lost interest in their previous major.

In a study that compared the effects of learning methods on social and academic integration, Severiens and Schmidt [9] found that students in the Problem-Based Learning (PBL) curriculum achieve a higher level of social and academic integration than students in a conventional curricula. A study by French, Immekus, and Oakes [10] to examine a model of student success and persistence found that increased levels of student interactions have a significant effect on persistence, but participation in the engineering first-year seminar did not impact persistence. Burtner [8] reported that students' confidence in college-level math/science ability and the belief that an engineering degree enhances career security influenced their persistence in engineering.

The decisions to stay or leave engineering programs are most often made in the first year; hence, the potential returns on institutional investment in student retention are likely to be greatest during the freshman year. Therefore, it is imperative that an effective foundation for student success is established for first-year students. However, most institutions have not been able to implement actions to achieve substantial gains in student persistence [11].

Institutional support processes to increase student retention will include adequate teaching and advising, faculty guidance and academic support, personal encouragement and attention from faculty members, and faculty and administrative efforts to enhance student learning.

Strategies for connecting students early on to the institution through academic advising, mentoring, learning communities, first-year residence halls, involvement and engagement, faculty and staff approachability, and other student support services are the vital links in the retention and persistence equation.

Academic advising and mentoring are powerful tools in connecting students to the institution by providing them guidance in developing decision-making skills necessary for them to persist. It is imperative that students feel a sense of connectedness with fellow students, as well as faculty and administrative staff. Institutions can create an out-of-class forum where students can freely express themselves on various issues without being judged. These can be accomplished by soliciting, from students, anonymous topical ideas that students would be interested in discussing. Academic and social integration requires time and effort by the student and the institution. Academic integration involves contacts between students and faculty inside the classroom as well as outside of the classroom. Therefore, institutions can provide support strategies that connect students to the campus and develop processes to ensure that students are provided with high-impact learning experiences.

According to Vincent Tinto [4], "integration through informal peer group associations, semi-formal extracurricular activities, and/or contact with faculty and administrative personnel, results in varying degrees of social communication, friendship support, faculty support, and collective affiliation." This becomes part of students' generalized evaluation of the costs and benefits of choosing engineering as a major, and presumably increases the likelihood that students will stay the course and become engineers.

An engineering curriculum should be designed to enhance student education. Inquiry-based and problem-based learning are student-centered approaches suitable for improving student learning by appealing to the curiosity of the student with a focus on questioning, critical thinking, and problem solving. In an inquiry-based approach, the tutor facilitates learning by encouraging and expecting higher-order thinking from students and providing them with information that leads to the development of a solution. In a PBL approach, the tutor supports the process and expects students to make their thinking clear, and students have the responsibility to provide the information that leads to the development of a solution [12].

CONCLUSIONS

Increasing student persistence and graduation rate in engineering education is vital to the U.S. competiveness. The economics of recruiting and retaining students in engineering programs indicates that increasing student retention rate is a cost-effective way of increasing the engineering workforce. Achieving this important goal will require concerted efforts of the faculty and the administrative staff to commit needed resources in addressing the structural issues that impact student retention and persistence. Students who take advantage of various integration opportunities provided by the institution are more engaged, and the frequency of the engagement will impact their retention and persistence.

This paper has focused on interventional strategies for transforming teaching and learning, and increasing students' curiosity and engagement in science and engineering with the objective of increasing persistence, reducing attrition, and completing an engineering degree program. The success of these strategies depends on the ability of the institutions to implement and maintain them to significantly enhance student persistence in engineering.

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