Who graduates from STEM, Who does not, and Why does it matter?

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Abstract - **Tracking retention rate is an important factor given the complexity of establishing the factors leading to an increase or decrease in graduation rates, especially in engineering programs that on a national level cannot meet the demand. It enables the institution to assess the periodic progression of students in its programs. As such, it can be used as an indication of: suitability of teaching methodologies, student expiates, curricular support structures, or the environment in a program or academic unit. Although by itself retention cannot answer definitively answer causality questions, educators can begin to determine where issues may be present to gather further data that can help understand the experiences of students should use it. Prior engineering educational research indicates that engineering programs experience immense challenge in ensuring effective retention rates in the first and second years of study. On a practical level there are too few engineers to meet growing demand so programs continue to evaluate them themselves to improve retention rates. This study considers the graduation and retention rates from the engineering programs at Youngstown State University (Chemical, Civil, Electrical, Industrial, and Mechanical) for the past 6 years (2006-2012). From the perspective of who goes into engineering and who is retained. The approach is to track students starting in the First- Year Engineering Program and determine where each of the students are today (enrolled or graduated from YSU outside of engineering, enrolled or graduated from YSU within engineering, transfer students into engineering, transfer students out of engineering). The direct assessment will come in the form of tracking retention (frequency counts, proportions, and simple statistical tests – gender, race / ethnicity, high school preparation). Once we determine student pathways (graduation, succession, and exit rates) we can establish a continuous procedure to track retention on an on-going basis and propose recommendations for improvements in the engineering program (based on the type(s) of students who do not persist in engineering)**

Index Terms - attrition, engagement, migration, persistence

BACKGROUND

Youngstown State University is an urban, public, research university in Northeast Ohio with a wide variety of higher education programs and majors serving ~13,000 undergraduate students, 86% of which come from within the state of Ohio. It is a very accessible school for students of diverse academic preparations and socioeconomic status. Specifically, it guarantees admission to any student earning a high-school degree or GED equivalent (although some programs, including engineering, do have restricted admissions). The STEM College is 72% male and 28% female and 15% minority student population. Most students in the STEM College are of traditional college age (80% less than 25 years old), are full time students (85%), and live off campus and commute (90% commute). The STEM College had a total enrollment in the fall of 2012 of 2,833 students, including 184 graduate and doctoral students, and 36 non-resident aliens.

The First-Year Engineering Program (which is part of the STEM College) had ~215 incoming students in the fall of 2012. Of those students, 84% were male, 16% female. In terms of race / ethnicity 86% were white, 14% underrepresented minorities. It is a general program such that all intended engineering disciplines take the same courses including:

(1) ENGR 1500 – Engineering Orientation – 1 Credit (fall)
(2) ENGR 1550 – Engineering Concepts – 2 Credits (fall)
(3) ENGR 1560 – Engineering Computing – 3 Credits (spring)

But beyond the First-Year Engineering Course sequence (and the fundamental mathematics, chemistry, and physics courses) students move to one of five ABET accredited engineering programs: Civil, Chemical, Electrical, Industrial, or Mechanical Engineering. There is no application process, rather as long as students have met the requirements of getting a C or better in Calculus, Chemistry, and Composition (the 3 C's) as well as the First-Year Engineering Program then they are transitioned over. Typically students graduate in 4-6 years, although there are certainly exceptions. This study was focused on better understanding retention and graduation rates, and specifically who is persisting and who is not.

INTRODUCTION

Engineers serve a critical role in different sectors of the economy. Nevertheless, the profession is experiencing challenges in the US as fewer engineers are available to meet the workforce demand (NAE, 2004; NAS, 2005). This shows a promising growth opportunity for young professionals entering the workforce. Statistics from the U.S Bureau of Labor Statistics indicates a project growth of 43% in the engineering and computer fields between 2004 and 2014, which translates to a 4% yearly increase in terms of job availability for engineers (U.S Department of Education, 2006; Hacker, 2005). This is coupled by the gradual exit from the engineering sector by professionals who have reached retirement age. Despite this, there was constant enrolment for engineering bachelor programs from mid 1980s to 2003 (National Science Board, 2006).

Another emerging issue is the impact that the shortage of engineering professionals will have on the level of high level of innovation associated with the U.S. Indeed, the decline in enrolment of engineering students in Bachelor programs has a direct impact on the associated research activities that provide the pipeline for innovation (NAS, 2005). Gradually, the U.S has fallen behind other nations when it comes to producing leading scientists and engineers. To illustrate this, 60% of bachelor program students graduating in China are primarily from engineering and science based courses while in the U.S this figure is at 30% and only 5% of this group are engineering graduates (Friedman, 2006; NSB, 2006). Consequently, this affects competition in terms of innovation and global competitiveness.

Despite the fact that women make up 56% of the entire U.S population, when it comes to their representation in the engineering graduates they only take up 20% (Grose, 2006). On the other hand, the number of minorities represents 30% of students attending college (National Science Board, 2004). The number of minorities is expected to increase to 37% of the U.S population by 2020 (National Centre for Public Policy and Higher Education, 2005). Many changes have taken place since 2001 when only 13% of the minorities earned or enrolled in engineering degrees in the Bachelor program. This implies that more attention needs to be given to minorities and women in terms of their recruitment into Bachelor engineering programs. This should be able to bridge the gap created by the shortage of professionals in the engineering sector. According to the National Science Board (2007), the Federal government needs to come up with new ways of increasing success in engineering and science-based courses.

These problems point to two major emerging issues that are silently affecting the engineering bachelor programs: student recruitment and retention. This needs to be taken as a serious matter among teaching and engineering faculty members. According to Dew (2007), there is need for the higher education sector to improve the teaching methods and quality aspects that will lead to better management. Among these quality aspects is the level of student success and completion rates in critical courses. The fact that available data shows an increasing shortage of engineers, having higher retention rates is a suitable factor. According to Clough (2006), the graduation rate of students enrolling in engineering bachelor programs in the US is 55%. This means that close to a half of those who enroll either decide to change to other programs or drop out. In this regard, improving this rate will lead to a significant increase in the number of engineers successfully joining the professional world and addressing the shortage. One of the most important areas of improvement is the first-year engineering student retention rate. This refers to the number of engineering students that proceed with their respective engineering programs past their first-year Tinto (1993), indicates that the freshman year tends to have the lowest retention rates compared to other college years. As such, it forms an important attribute for consideration.

An important step in addressing engineering student retention is to evaluate who does not continue in engineering after their first-year and why. This is critical to understanding the existing undergraduate engineering graduation rates who are the "supply" for the previously mentioned national demand for qualified engineers. The fact that the first-year engineering student retention rates are lower than subsequent years, it deserves to be given priority as one of the areas that need focus.

Prior studies of first-year engineering student retention rates have looked at both single and multiple institutions. For example, prior studies focused on multiple institutions indicated that the level of high school preparation, science preparation, math preparation, intensity of school curriculum, science based orientation, and display of an aspiration of taking up a career in engineering as significant predictors at national level (Astin & Astin, 1992; Adelman, 1998). More specifically, the Astin and Astin study assessed pre-college factors that affect retention such as mixed expectations of college experience and attitudes at high school level towards engineering. The study showed that students begin having a poor attitude towards technical courses such as engineering and they also think that it will make their college experience more challenging.

Indeed, given the level of standardization provided through admission of similar SAT/ACT admission tests or admission of similar surveys across different institutional settings provides a higher possibility of getting a better prediction trends to understand the subject. On the other hand, focusing on multiple institutional settings has its own disadvantages. Among the disadvantages include the complexity in modeling the interaction between different variables and decreased efficiency in the implementation of intervention measures.

Focusing on a single institution makes it manageable to model the interaction among different variables in the study. It also makes it easier in identifying challenges that emerge when implementing an intervention; hence, easy to understand issues regarding student retention. In essence, student retention refers to the measures that an

institution puts in place to support students in meeting their academic objectives and success levels. The institution is responsible for promoting a suitable climate that molds the student academically and socially through provision of educational material, curriculum implementation, and educational advice. Indeed, by focusing on a single institution, it enables the researcher to look at interaction between variables in detail. According to Braxton (2000) and Dey (2007), there is need for more single institution focus studies to better understand student retention issues. Additionally, a single institution study enables the researcher to look into issues regarding school preparation levels.

Veenstra and Herrin (2006) remark that funds provided to support student research activities tend to be lower in public universities compared to private ones. Focusing on multiple institutions will imply less funds being available to conduct sufficient research. As such, focusing on a single institution will ensure prudent use of funds while attaining better outcomes.

Methods

The primary research method used in this study involved researching historical graduation data collected by Institutional Research at Youngstown State University. Specifically, students were tracked that started in the first semester, First-Year Engineering course Engineering Concepts (ENGR 1550) each year from 2005-2012 and tracked them through the university. The data was considered in terms of the retention and persistence of students through First-Year Engineering into the five ABET accredited engineering programs at YSU, including Chemical, Civil, Electrical, Industrial, and Mechanical.
Looking back at the starting cohorts of students (starting in the First-Year Engineering Program) we will determine where each of the students is today:

(1) Enrolled in engineering at YSU
(2) Graduated from engineering at YSU
(3) Enrolled in another program outside of engineering at YSU
(4) Graduated from YSU from a program outside of engineering
(5) Or students that are no longer affiliated with the university (transfer, drop –out, taking a break, etc.)

Once we determine student pathways (graduation, succession, and exit rates) we can begin to tackle the bigger retention question outlined initially of who goes into engineering, who stays in engineering, and why. Data is analyzed closely including: retention through the first year, retention from the first-year to the second year, within each engineering discipline, to graduation / graduation rates, by gender, by race / ethnicity, and by high school preparation levels (SAT / ACT / AP Credits/ etc.).

Results / Discussion

Data provided in this paper will analysis 7 cohorts of students ranging from 2005 until 2012 enrolled in Engineering Computing (ENGR 1550) in Youngstown State University. General statistics on the population in terms of count:

Table 1.Count of Male and Female Students Enrolled in ENGR 1550 (Engineering Concepts) 2005-2012

Gender	2005	2006	2007	2008	2009	2010	2011	2012	Total
Male	106	123	127	123	120	143	147	176	1065
Female	20	20	23	24	12	21	21	32	173
Total	126	143	150	147	132	164	168	208	1238

Table 2.Count of Male and Female Students by Racial Group Enrolled in ENGR 1550 (Engineering Concepts) 2005-2012

Gender	Black	Hispanic	Asian	Non-Resident	Unknown	White	Multiple	Other	Total
Male	37	29	10	14	82	886	6	1	1065
Female	8	7	4	1	9	140	3	1	173
Total	45	36	14	15	91	1026	9	2	1238

Figure 1 is a summary of graduation majors of 321 engineering students that began in the First-Year Engineering Program in 2005-2012 The majoity of students graduated from engineering, 68%

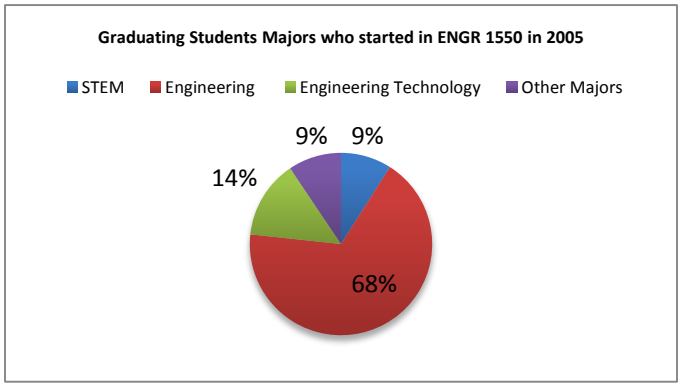

FIGURE 1
GRADUATING STUDENTS MAJORS WHO STARTED IN ENGR 1550 IN 2005

Figure 2 is a summary of 506 current students major that began in the First-Year Engineering Program in 2005-2012 The majoity of students are still in engineering, 70%

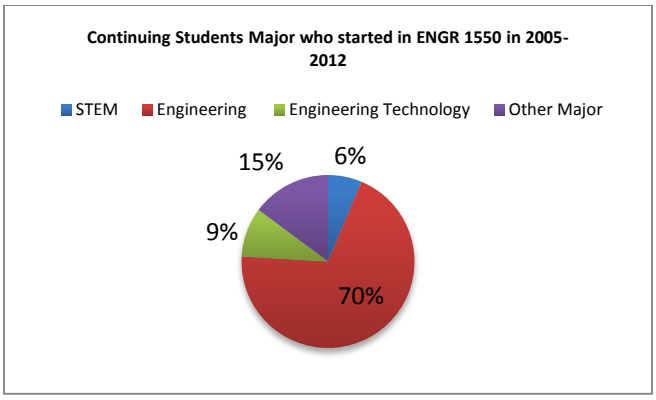

FIGURE 2

CONTINUING STUDENTS MAJORS WHO STARTED IN ENGR 1550 IN 2005-2012

Figure 3 is a summary of 321 engineering students graduation rate since beginning in the First-Year Engineering Program in 2005. The majoity of students graduated within 4 years, 54%

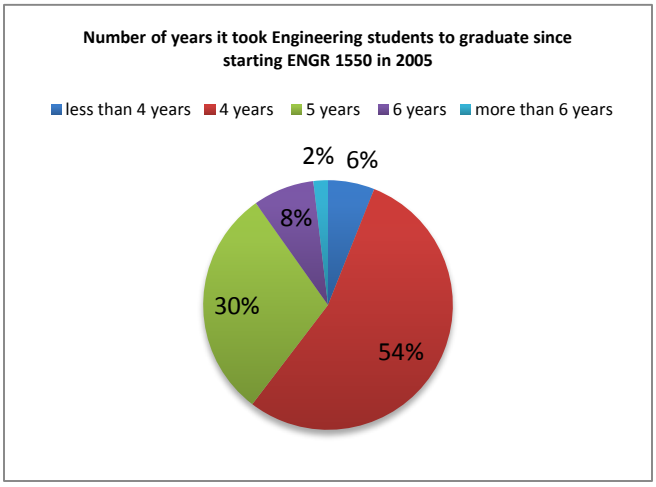

FIGURE 3

NUMBER OF YEARS IT TOOK ENGINEERING STUDENTS TO GRADUATE SINCE STARTING IN ENGR 1550 IN 2005

CONCLUSIONS

Retention rate is an important metric given the complexity of establishing the factors leading to an increase or decrease in graduation rates. Among the factors affecting graduation rates, as identified in the literature review, include financial aid issues to support personal challenges that engineering students experience, ineffective teaching strategies that do not promote retention, curriculum issues affecting successful progression of students to their majors, low prequalification of students entering engineering programs to meet advertisement, and special factors affecting minority groups in the engineering courses.

At Youngstown State University the engineering retention rate is 68% to graduation, and based on the comparable rate of 70% of students still pursuing an engineering degree but have not yet graduated that appears to be a stable number. Between 10-15% of students move on to other majors within the university – and some natural attrition is to be expected (just as some students transfer into engineering, some also transfer out) but this is the group that is the focus for the future to understand at what point students leave engineering and for what reasons. A limitation of the current study is that data are based on a single institution.

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Gelan Badr graduated from Tennessee Technological University in 2012 with a BS in Business Administration. She started her Industrial Engineering master's program at Youngstown State University (YSU) currently she is working on her master's thesis on retention graduates in Engineering at Youngstown State University. Gelan plans to graduate in Fall 2013 and apply for her PhD for the following semester in Industrial Engineering at the University of Pittsburgh.

Dr. Meyers background is in Engineering Education with experience in assessment, specifically of programs that might influence an incoming student's experience, affect retention rates and the factors that determine the overall long term success of students entering an engineering program. She is the Director of the STEM College's First-Year Engineering Program, the entry point for all beginning engineering students designed to provide a smooth transition from high school to University. Previously she was involved with the First-Year Engineering Program at the University of Notre Dame.

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