Understanding the reasons behind the decreasing enrollment numbers in engineering programs in the United States

Niranjan Desai, Ph.D
Assistant Professor, Department of Civil and Mechanical Engineering, Purdue University Northwest

Lucas Neuhold
Student, Department of Civil and Mechanical Engineering, Purdue University Northwest

Abstract

Engineering programs in the United States are faced with the challenging problem of decreased enrollment levels at the undergraduate level. This paper explores possible reasons behind this by obtaining feedback from high school students in order to understand their perspective. Junior and senior year high school students are surveyed on what career path they can see themselves pursuing and why, their impression of the nature of work performed by an engineer, their exposure to basic mathematics and physics that will prepare them for engineering, their interest in studying these subjects, their level of motivation to put in the hard work needed to master abstract concepts while studying these subjects, their awareness of the different opportunities for financial aid to support their college studies that they have access to, the requirements that they need to fulfill in order to satisfy admission criteria for undergraduate engineering programs, and the direction and support that they receive from the administration and faculty in their local high school while considering what they might want to study in college. The survey feedback is analyzed, based upon which recommendations are made that attempt to increase enrollment in undergraduate engineering programs.

Keywords

Attrition, Retention, Engineering

Introduction

There exists a scarcity of qualified engineers in the workforce in the United States. Obtaining a college education has been shown to lead to financial success[1]. Yoon and Strobel[2] have found that the interest level among high school students to pursue engineering degrees is low, and is strongly influenced by 12th grade performance in and exposure to math and science courses. It is common knowledge that retention rates in engineering programs are declining[1,3,4], and lie in the range of 40-60%.

A survey was distributed among high school students in order to obtain information that could potentially provide insights into the reasons for these decreasing enrollment and retention rates in engineering programs at the college level and possible solutions to these problems. This paper describes the process used to obtain these results, a presentation and analysis of the results obtained and the conclusions that were drawn based upon these results.

Methodology

This study was motivated by feedback that was obtained from undergraduate engineering students at the author's institution regarding potential reasons for the decline in enrollment rates in engineering programs at the college level in the United States. Based upon this feedback, three hypotheses were postulated: 1) lower enrollment in engineering programs was due to high school students being unprepared in mathematics and physics; 2) Low STEM enrollment was due to a lack of interest and motivation in putting in the work needed to master complex, abstract concepts in these subjects; and 3) inadequate awareness of the various opportunities for financial aid to support themselves over the course of their engineering major, and about the college admission process and requirements. These requirements might be known to students from families comprising college educated parents. However, first-generation college students might not be as aware of this information.

In the context of withdrawal from engineering programs, reasons were similar to those stated in the introduction (inability to cope with calculus and physics, inability to deal with the stress created due to the lack of family support and structure, etc.).

Based upon this feedback, a survey was constructed and distributed among high school students in a local high school. The response to each question was categorized on a Likert scale as very weak, to weak, to neutral, to strong, to very strong. The survey questions attempted to gain information regarding the students' levels of interest, motivation, and preparation in mathematics and physics, their knowledge of the college admission process and financial aid possibilities, their knowledge of the work load expectations of engineering students, and their awareness of an engineer's role, quality of life, and financial compensation.

This was an initial, small-scale pilot study involving one local high school, to establish a process to obtain high school participation in a study of this sort and to ensure the study survey was distributed to the students and the results collected. The participating high school was very cooperative due to the fact that the author's institution has a dual credit program in place with this high school and the administrators of this program have developed a relationship with their counterparts in this high school. Based on these preliminary findings, this research will be expanded to include 45 local high schools in the surrounding counties that have a similar relationship to our institution.

The pilot study was performed to ascertain the validity of the study, the feasibility of expanding the study, and the quality of feedback obtained. The success of this pilot served as a positive indicator, based upon which the large-scale follow-up study can be performed with a reasonable likelihood of obtaining useful information.

A unique aspect of this study was that it was performed in collaboration with an undergraduate student from the local community, having valuable insights into the culture and thinking of the population in this area.

Analysis of the Data

The data obtained from this investigation reflects the feedback obtained from 135 college-bound juniors and seniors, since the majority of students surveyed were from the junior and senior year in high school (86%) and wanted to attend college (77%). Table 1 shows the results of this study.

The numbers shown are a percentage of the total number of students that participated in this study. For each question, the table shows the sum of the percentages for the "weak" and "very weak" responses, the percentages for the "strong" and "very strong" responses, and the "Neutral" response percentages.

Table 1: Survey Results

Question	Responses (%): very weak + weak	Responses (%): Neutral	Responses (%): very strong + strong
1	34.81	31.85	33.33
2	18.52	33.33	48.15
3	28.89	34.81	36.30
4	50.37	41.48	8.15
5	43.70	44.44	11.85
6	41.48	42.96	15.56
7	24.63	26.12	49.25
8	14.81	26.67	58.52
9	13.33	25.93	60.74
10	16.30	29.63	54.07
11	11.85	26.67	61.48
12	32.59	37.04	30.37
13	32.59	37.78	29.63
14	29.63	39.26	31.11
15	40.00	43.70	16.30
16	31.85	28.15	40.00

The responses to question 1 (How would you describe your interest in mathematics) showed that only about a third of the students polled had an interest ranging from strong to very strong in mathematics. Despite this, based upon responses to question 2 (How would you describe your performance in mathematics?), nearly 50% of the students polled had a strong to very strong performance in Mathematics. Additionally, another one third had an average performance in the same. However, based upon responses to question 3 (How would you describe your level of motivation to put in the effort to understand and master rigorous mathematics concepts?), it can also be seen that only about 36% of the students had the motivation to put in the hard work need to understand challenging math concepts. Based upon these numbers, we can see that the percentage of students performing well in math is higher than that of students that have an interest in math, and are also willing to work hard at it. A possible conclusion that can be drawn from these numbers is that although students feel adequately prepared in math and perform reasonably well in a regulated environment, they might not necessarily have the motivation and adequate personal interest to independently study mathematics.

Responses to questions 4 (How would you describe your interest in physics) show that half the students surveyed said that they are either uninterested or very uninterested in physics. Only about 8% of the students have a genuine interest in the subject. As far as their physics performance goes, based upon responses to question 5 (How would you describe your performance in physics?), the numbers show similar results, with nearly 44% of respondents

saying that their performance in physics ranged from weak to very weak. Another 44% displayed an average performance and only about 11% performed well. Motivation to put in the required effort to master physics concepts was also low, as responses to question 6 (How would you describe your level of motivation to put in the effort to understand and master rigorous physics concepts) show. It can be seen that a large number of students not only lack interest or motivation to study physics, but they also have performed poorly in this area. This is an important result, because just like mathematics, physics is an essential and core component of engineering. Only a small percentage of students appear to have the necessary interest and motivation, backed by performance, in order to succeed in an engineering program. These numbers could be a possible reason why enrollment in engineering programs in college is declining.

The response to question 7 (Based on your current knowledge of introductory Science (Physics, Chemistry, and Biology) and Mathematics, how would you describe your current level of preparedness to pursue a STEM (Science, Technology, Engineering and Mathematics) Degree?) shown below reflects that half the students currently feel either strongly or very strongly prepared to pursue a STEM discipline in college. Additionally, about a quarter of them feel that they have an average level of preparedness to do so. These numbers in isolation indicate that STEM enrollment should be high. However, the lack of interest or motivation of a majority of students to study math, and the overall poor physics-related numbers mentioned above, are possible reasons that despite the fact that a large percentage of students feel reasonably to very well prepared to enroll in STEM in college, enrollment numbers are still declining.

Responses to questions 8 (How would you describe your knowledge of possible financial aid avenues available to you for college?) and 9 (How would you describe your current level of preparedness of information you need to enter college [entrance exams (SAT, ACT, high school GPA, access to counselors, formal applications, entrance deadlines, required paperwork]?) in the survey show that the majority of students have either a strong (approximately 60%) or reasonable/average (approximately 26%) level of awareness of their financial aid options and the preparatory requirements that they need to fulfill prior to entering college. This is a reflection of their high school's ability to adequately inform them of the requirements to get accepted and pay for college attendance.

It can be seen from the responses to questions 10 (How would you describe your current level of preparedness to cope with the environmental changes of attending college [moving away from home, family, friends, and social support systems]?) and 11 (How would you describe your current level of preparedness to independently deal with the academic routine of college [homework, quizzes, tests, time management]?) that the majority of students polled (ranging from 54%-61%) of students feel very well prepared as far as coping with the environmental changes of moving to a college campus, moving away from family and friends, and being in a situation that requires them to be self – sufficient, self-disciplined, and function independently. Additionally, about a third of them feel reasonably ready to be able to deal with the aforementioned changes. This reflects that apprehensions about the transition to a college environment and all the challenges that it entails would not dissuade students from selecting STEM majors. However, research shows that these are factors that contribute to attrition in engineering programs[4]. Since the questions were generally applicable to all majors in college, it

appears as though the students do not necessarily have an accurate idea of the challenges that they will be faced with in engineering college specifically.

Responses to question 12 (How would you describe your current knowledge of STEM work load expectations at the college level?) shows that only a third of students are fully aware of the work load that a STEM major entails. A roughly equal percentage of students felt either totally unaware or moderately aware. The data displays that the students may not have an accurate idea about what STEM disciplines require of them. On comparing this with the responses to question 7, it can be seen that a much higher percentage of students feel well prepared to pursue a STEM degree as compared to those that are well aware of the work load expectations. It is possible that some students enter a STEM program and withdraw due to the unexpectedly high work load, leading to the increasing attrition numbers in these programs.

Responses to question 13 (How would you describe your qualitative knowledge of STEM field occupations [role engineers play, different types of engineering disciplines, nature of the work they do, the salaries they are paid, the lifestyle they have, their work-life balance, etc.]?) and 14 (How would you describe the financial rewards of working in STEM fields as a motivator to enroll in a STEM field in college?) demonstrate that approximately equal percentages of students felt well-informed, moderately informed or poorly informed regarding the qualitative aspects and financial rewards of a STEM – based occupation. Based upon these responses, it would be helpful to attempt to accurately gauge the level of student awareness about the aforementioned aspects of working in STEM, and, if needed, work toward increasing their knowledge and exposure to them. Additionally, by making students aware of these aspects, it might also increase their interest in math and physics, by contextualizing these subjects with respect to engineering and then linking engineering to their personal lives. Subjects studied in a vacuum may not be as interesting or appealing on a personal level as compared to subjects that can be associated with individuals' personal lives. Consequently, an increased interest in math and physics could lead to more students wanting to enroll in engineering.

It can be seen that the percentage of students that are motivated to pursue STEM disciplines due to financial incentives are approximately the same as those that are well informed about careers in STEM. A possible conclusion that can be drawn from these responses is that financial rewards show a correlation with enrollment in STEM disciplines.

Most students (about 84%) are not influenced by negative stereotypes of STEM degree aspirants as can be seen from the responses to question 15 (How influenced are you by any social stereotypes pertaining to students that pursue STEM degrees?). This makes it possible to eliminate peer pressure that young students face as a parameter that affects STEM enrollment.

In response to question 16 (How would you describe your likelihood to study in a STEM field in college?), about a third of students were clear about not pursuing a STEM discipline major in college. At the other end of the spectrum, about 40% of students had decided to enroll in a STEM major. About 28% of students polled were neutral regarding enrolling in STEM in college. Of the 40% that have decided to enroll in a STEM major, based upon the above discussion it can be concluded that some attrition will occur once they enter their chosen program. Hence, it would be beneficial to implement some changes at the high school level in

order to prevent this from happening, and also to increase STEM enrollment. Some of the conclusions drawn in this paper could provide potential hints and guidelines that could help accomplishing these goals.

Conclusions

A study was performed at a high school in Indiana to understand students' attitudes toward studying STEM majors at the college level, their level of preparation to do so, their knowledge of admission requirements to STEM programs and financial aid opportunities to support their studies, and their general impression and awareness of what being an engineer entails. The following conclusions were made:

1) High school students surveyed felt adequately prepared in math; 2) Physics seemed to be a subject in which quite a few students felt under prepared. This conclusion supports the first hypothesis upon which this study was based; 3) the majority of student feel either indifferent to, or very disinterested in both math and physics. Hence, simply preparing students in a subject is not equivalent to igniting their interest in this subject, as is apparent from the results in the context of math. This supports the second hypothesis upon which this study was based; 4) the representative High School is doing a reasonable job of informing students of the requirements for admission to a STEM program and financial aid opportunities. This contradicts an initial hypothesis of this study. It is necessary to perform a larger study involving more High Schools to further explore this hypothesis. 5) Given that a large portion of data was taken from seniors and juniors it's also obvious that they feel prepared to move on from the High School level to the college level in terms of mental and emotional preparedness. 6) Efforts of gaining enrollment in STEM should start at the High School level and should focus on making students prepared, as well as interested and motivated to learn math and physics. Students are unlikely to transfer to a STEM field after entering college, given the low retention rates in STEM programs[4].

A possible solution to increasing student interest in STEM fields may be to conduct collaborative bridge programs focused on physics between the high schools and colleges in the local area, and also to implement strategies to increase their levels of interest and motivation to study both math and physics. High schools increasing the proficiency of their physics program would be a step in the right direction. Along with this, visits from STEM experts such as professors and industry personnel to local high schools, where they explain in simple terms to students what these fields can offer them, could help incentivize students to enroll in STEM majors in college. Finally, if these individuals can normalize engineers and emphasize to high school students that becoming an engineer is an attainable goal for them, some of the students that feel disinclined or neutral to enrolling in STEM fields due to a lack of confidence in their skills could be persuaded to enroll in a STEM major in college.

Acknowledgements

We would like to thank Dr. Lindsay Gielda, Assistant Professor of Biology at Purdue Northwest for helping us construct the survey and distributing it to the high school with the help of her network there. We would also like to thank Michelle Salomon at the local High School for participating in this study and being so cooperative with us.

References

[1] Santiago, Lizzie and Robin Hensel, "Engineering Attrition and University Retention", ASEE Annual Conference and Exposition, June 10-13, 2012, San Antonio, TX.
[2] Yoon, So and Johannes Strobel, "Trends in Texas High School Students' Enrollment in STEM Courses for Career and Technology Education". 123rd ASEE Annual Conference and Exposition, New Orleans, LA, June 26-29, 2016.
[3] Krause, Stephen, James Middleton, and Eugene Judson, "Factors Impacting Retention and Success of Undergraduate Engineering Students", 122nd ASEE Annual Conference and Exposition, June 14-17, 2015, Seattle, WA.
[4] https://www.insidehighered.com/news/2013/11/27/study-tracks-attrition-rates-stem-majors

Biographical Information

1. Niranjan Desai is an Assistant Professor in the Department of Mechanical and Civil Engineering at Purdue University Northwest. He earned his Ph.D in Civil Engineering from the University of Louisville. His research interests include engineering education and structural health monitoring. In engineering education, he is interested in developing innovative strategies to improve the learning experience for students, and analyzing the enrollment and retention trends of students in engineering programs in the United States and developing ways to improve these numbers.
2. Lucas Neuhold is a junior year undergraduate student in the Department of Mechanical and Civil Engineering at Purdue University Northwest.