Factors that Influence Engineering Freshman to Choose Their Engineering Major

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Abstract

Over at least the past quarter century, engineering educators and even the national press have viewed with concern the declining interest of US students in the STEM disciplines relative to other choices available to students. Within engineering and computer science, educators are coping with large increases in undergraduate enrollment in some disciplines (for example, mechanical engineering) and large declines in enrollment in others (for example electrical engineering and computer science after the "dot com" collapse[1]). Over a period of four academic years, Binghamton University has held a student survey designed to rank the factors which influence choice of major. This work examines the results of these surveys, as collected from a pool of approximately 300 freshman engineering-intended majors, each year. Three factors were rated by students as most important in their major selection process: (1) Personal Academic Interests; (2) Potential for Societal Contributions; and (3) Job Prospects. Students also had a high degree of support for "Decision Before Freshmen Program."

Introduction

As at many universities, Binghamton University has a common first year for engineering majors. Binghamton University is a medium sized state-supported comprehensive university, with approximately 12,000 undergraduate students and 3000 graduate students. Engineering disciplines within the college of engineering and sciences include bioengineering (BE), computer engineering (CoE), electrical engineering (EE), industrial and systems engineering (ISE), and mechanical engineering (ME). Students with initial interest in any of these disciplines enter the university as an "undeclared" engineering major, and are formally in the Engineering Design Division (EDD), part of the Watson School of Engineering and Applied Science at Binghamton University, for their first year. The college of engineering and science also includes computer science, but the computer science discipline has a separate first year experience for freshmen, due to the differing requirements in that field. All the intended engineering majors enroll in a set of common engineering courses (8 credits total over two semesters), which are intended to expose the students to all options within engineering at our university, and also to develop their technical writing and speaking skills. Although enrollments vary from year to year, the average enrollment in EDD over the past four years has been about 300 students. In addition to a large common lecture section, the students have labs and writing/speaking activities in smaller groups of about 30 students. The "Exploring Engineering" course includes technical lectures, presentations from departmental representatives, and many hands-on activities.

The objective of this paper is to summarize the results of surveys conducted over each of the past four years of the engineering majors. The surveys were intended to gauge student opinions as to why they selected their declared major. Surveys were administered in April of each year, in the common engineering design class taken by all of the students.

Background—the first year curriculum at Binghamton University

More details of the first year of engineering at Binghamton University are given in Rampelli[2]. However, a brief description is given here to provide context for the current paper. Figure 1 depicts the common first year curriculum for all engineering majors at Binghamton University. Of most relevance here is the 8-credit Engineering Design Division (EDD) sequence (WTSN 103, 104, 111, 112 courses, each 2 credits and 1 semester long). Of these four WTSN courses, 103 and 104 are primarily communications oriented (writing and speaking), whereas 111 and 112and112 have more core engineering content. The supporting courses are tightly integrated; writing and presentation assignments in 103 and 104 support lectures and lab content from 111 and 112. The 103 and 104 courses meet in small sections only, with about 32 students per section. The 111 and 112 courses have both a large lecture section (with all ~300 students), and also small lab sections, again with approximately 24 students per section.

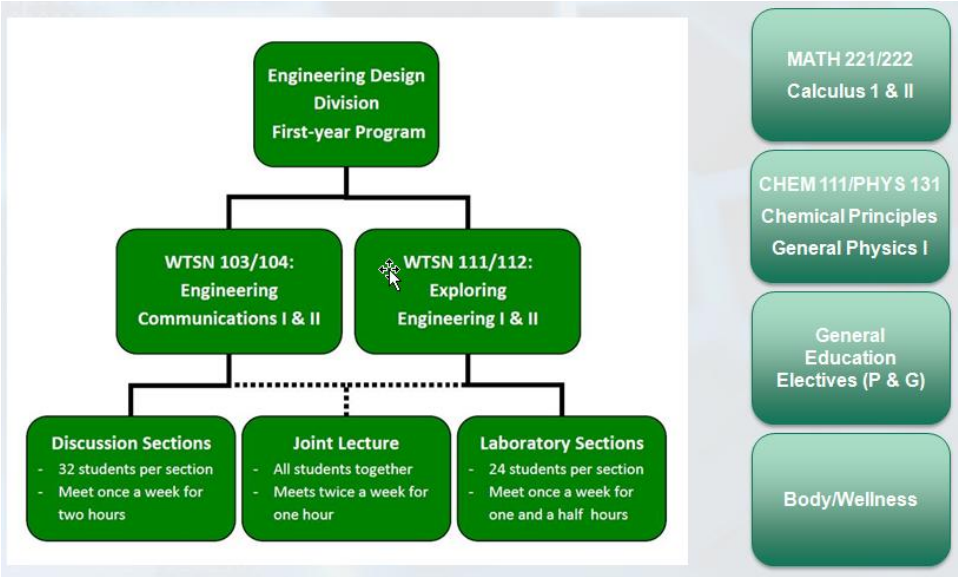

Figure 1. Overview of freshman engineering curriculum at Binghamton University

The main intent of these WTSN courses is to expose students directly to hands-on engineering in their first year of college, as well as to help them make a more informed decision as to which engineering major to select. As has been noted in several studies[3-7] it is believed that the high attrition rate of engineering majors between freshmen and sophomore years is related to the student-disconnect between the difficult and theoretical math and science intensive curriculum which is common in most engineering programs and the engineering hands-on design-oriented types of things intended engineering majors are most interested in. Salient characteristics of WTSN 111 and 112 include several lectures and labs on engineering design topics spanning several areas (such as basics of digital circuit design, an Arduino system design), small design projects (such a simple mechanical design using Solid Edge), a larger design project (essentially reverse engineering of some device), and guest lectures by departmental representatives,

which give a broad overview of what each major involves, the curriculum for that major, and typical job types for graduates of that major.

Tables 1 and 2 present the total beginning enrollments over the past four years in the fall semester for WTSN 111, the number of students who actually selected an engineering major at the end of the spring semester of the following year, and the breakdown by majors selected. Table 1 gives the actual number of students for each entry, whereas Table 2 lists percentages, based on the students who actually chose to remain in engineering. The totals of the majors in Table 1 do not sum to total registered for WTSN 111, since some 111 students did not stay in engineering. However, Table 2 also has a row for retention rate of students, computed as the percentage of students enrolled in WTSN 111 who continue to choose an engineering major at the end of freshman year. One observation from this data is that the percentage of students selecting each major is fairly consistent year to year, with mechanical engineering by far the most popular major. Over longer time periods, trends emerge, such as the mild increase in the selection of the CoE major and mild decrease in the selection of the ISE major, over the past three years. The student retention rate increased substantially from 2008-2009 (67.5%) to the following year (84.3%), and remained in the 80%+ rate for the following two years. The primary instructor and head of the EDD changed beginning in 2010, but this is one year after the increase in retention rate.

Table 1. Binbhamton University engineering major selections—number of students selecting each major. The "111" row indicates the number of engineering students at the beginning of the fall semester.

WTSN 111 enrollment and WTSN 112 major selections				
	2008-2009	**2009-2010**	**2010-2011**	**2011-2012**
111	378	267	321	317
BE	28	29	28	37
CoE	27	26	35	38
EE	26	33	39	40
ISE	61	67	65	56
ME	113	70	97	99

Table 2. Binghamton University engineering major selections—percentage of students selecting each major as well as retention of students in engineering.

WTSN major selections (%)				
	2008-2009	**2009-2010**	**2010-2011**	**2011-2012**
BE	11.0%	12.9%	10.6%	13.7%
CoE	10.6%	11.6%	13.3%	14.1%
EE	10.2%	14.7%	14.8%	14.8%
ISE	23.9%	29.8%	24.6%	20.7%
ME	44.3%	31.1%	36.7%	36.7%
Retention rate	67.5%	84.3%	82.2%	85.2%

The "Factors" Survey

In order to obtain a better understanding of the factors which influence the major selection of engineering-intended students, a short 10-question survey instrument was created, as given in Table 3. This survey was given to the students before major declarations were made but near the end of the spring semester. The survey was always given in WTSN 112, either in class as a "clicker" survey or a "required" online (blackboard) homework assignment. In addition to the "factor" questions, students were asked to indicate which engineering major they expected to select. Results in terms of numbers of students completing the survey, and selection of majors, are given in Table 4, both as actual numbers and as percentages. On average, a little more than half the students enrolled in WTSN 112 completed the survey. The results in terms of majors selected are a sampling and roughly similar to those of the actual ultimate declared majors, as given in Tables 1 and 2. However, the majors selected in the survey are more heavily weighted towards electrical and computer engineering majors (EE, CoE), presumably since the survey was typically given in a class presented by an ECE faculty member who was giving a guest lecture on the nature of electrical and computer engineering. As lecture topics were announced in advance, students interested in electrical and computer engineering were most likely to attend these lectures.

Table 3. Survey instrument given to students

Directions: We are conducting this survey to better understand what factors you used in choosing your declared major. We are not asking for your name, just your honest input. Please answer the following statements to the best of your ability according to the following scale and record your answers on the electronic score sheet provided.

A = Strongly Agree **B** = Agree **C** = Neutral **D** = Disagree **E** = Strongly Disagree

1) I was already pretty sure which engineering program I wanted before coming to Binghamton University, and I did not change my mind.

2) The WTSN 111/112 lectures helped me to decide my major.

3) The labs and project in WTSN 111/112 helped me decide my major.

4) The faculty members from the academic departments who gave guest lectures helped me decide my major.

5) Input from upper class students helped me decide.

6) The levels of difficulty of the various majors helped me decide the major.

7) My family and/or friends helped me to decide my major.

8) I believe the major I chose will best allow me to contribute to society.

9) I believe the job prospects will be the best in the major I chose.

10) My personal academic interests best match the major I chose.

11) Which major did you choose? Please pick from the following choices and record your answer. Please leave blank if you have not yet decided on an engineering major or have a major other than the ones listed.
A = BioE **B** = CoE **C** = EE **D** = ISE **E** = ME

Table 4. Binghamton University engineering major selections as indicated by student survey.

Major selections as per survey				
	2008-2009	**2009-2010**	**2010-2011**	**2011-2012**
BE	23 (12.1%)	26 (12.5%)	9 (8.3%)	24 (12.8%)
CoE	16 (8.4%)	23 (11.1%)	23 (21.3%)	24 (12.8%
EE	17 (8.9%)	31 (14.9%)	34 (31.5%	30 (16.0%)
ISE	48 (25.3%)	62 (29.8%)	11 (10.2%)	43 (23.0%)
ME	86 (45.3%)	66 (31.7%)	31 (28.7%)	66 (35.3%)

Survey "Factor" Results

Average results from the students for each of the four years are shown in Figure 2 (averaged over all students), and in Figures 3-8 for subgroups of students according to the major they indicated they intended to choose (BE, CoE, EE, ISE, ME, and other, respectively). The "other" category includes students who had not made up their mind about a major at the time of the survey, and students who decided to switch out of engineering. Averages were computed using weights of 5 for strongly agree, 4 for agree, 3 for neutral, 2 for disagree, and 1 for strongly disagree. Thus high-numbered strengths of influence indicate more student support for the importance of a particular factor, while lower numbers indicate less support. Any value above 2.5 shows at least some support, on average. The survey instrument was not discussed with students, and

students were free to interpret each question however they felt most appropriate. For example, responses to "influence of upper-class students" might have been due to limited interaction with these students, or lack of discussion about majors with these students, or anything deemed significant to the surveyed students.

Discussion of "Factor" Results

The results for the students overall, and the majority of subgroups of students, indicate that, of the factors examined, three factors seem to have the most influence on student selection of major: (1) Personal Academic Interests; (2) Potential for Societal Contributions; and (3) Job Prospects. To a lesser degree, but fourth ranked in importance overall, students indicated that "Decisions Before Freshman Program" had a strong influence. Of the factors evaluated, the least significant in helping students choose engineering major were: (1) Class Lectures; and (2) Perceived Difficulty of Major. Note that these are only general observations, with considerable variability from year to year and major to major. Interestingly, only 1 factor emerged as very consistent from the "all" group of students from year to year— the influence of upper-class students.

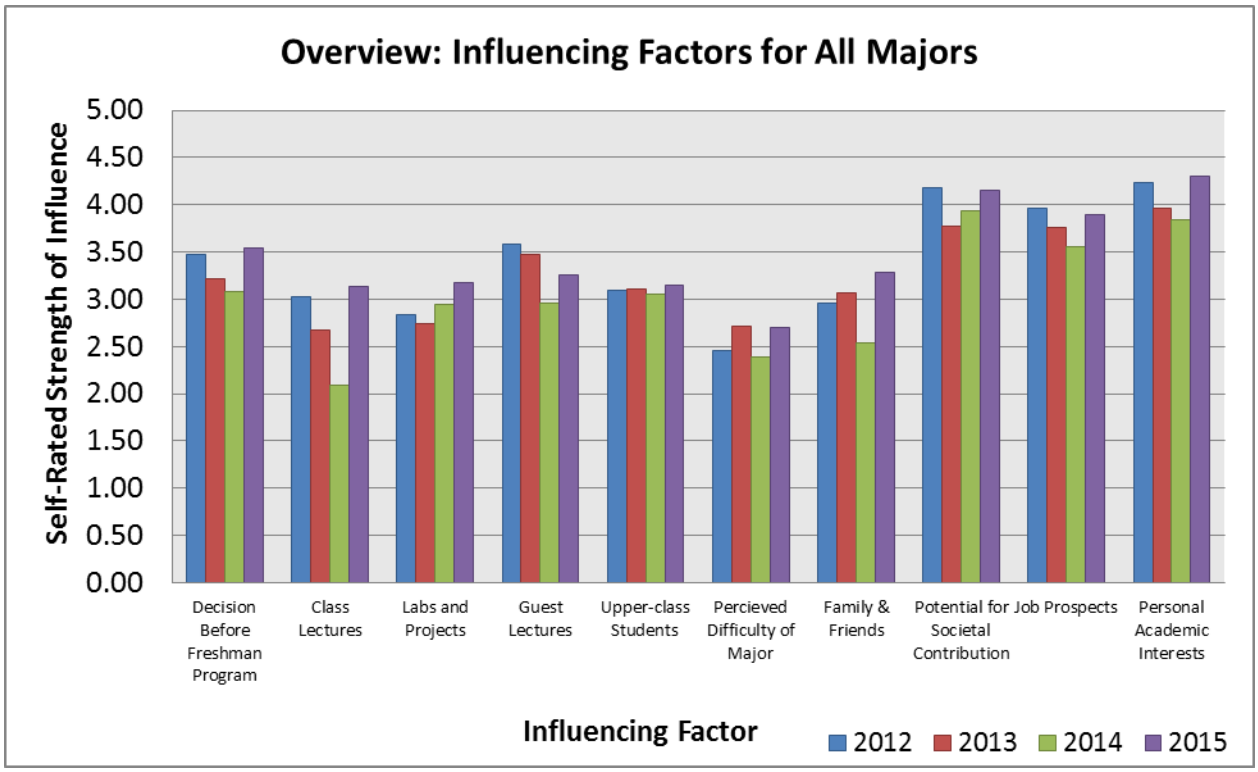

Figure 2. Factor ratings for "All" students.

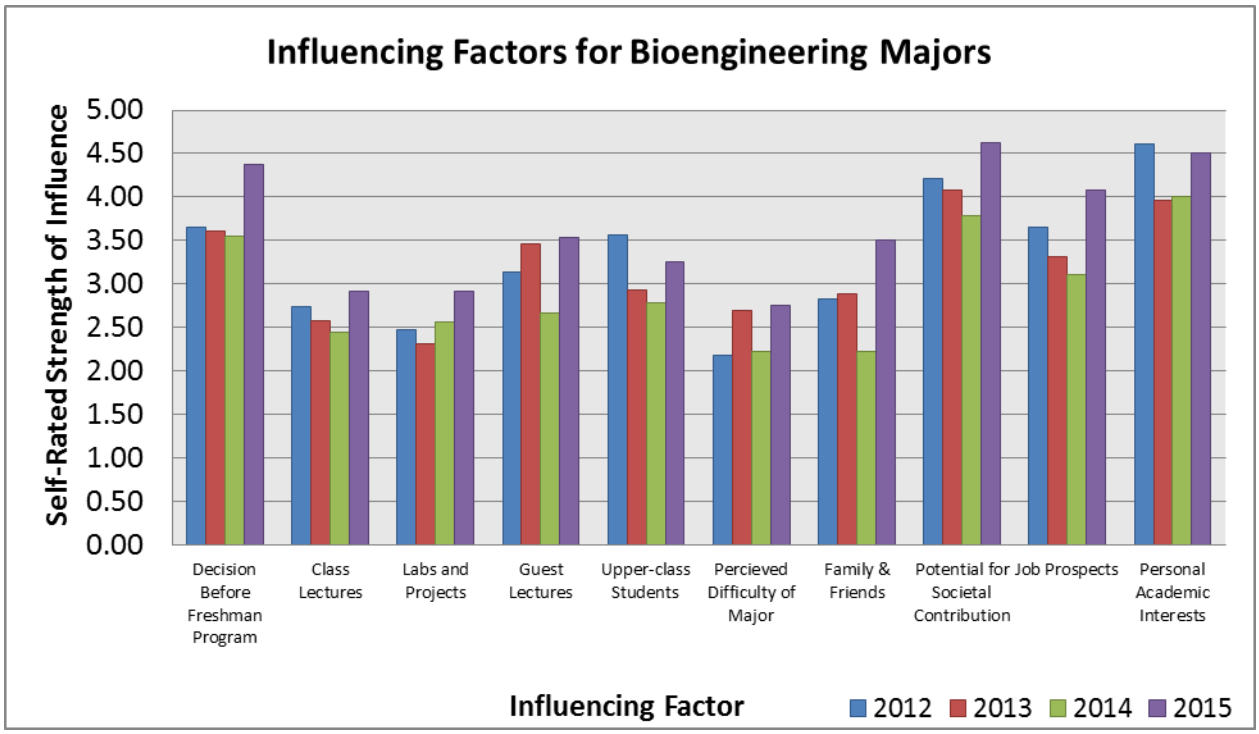

Figure 3. Factor ratings for "BE" students.

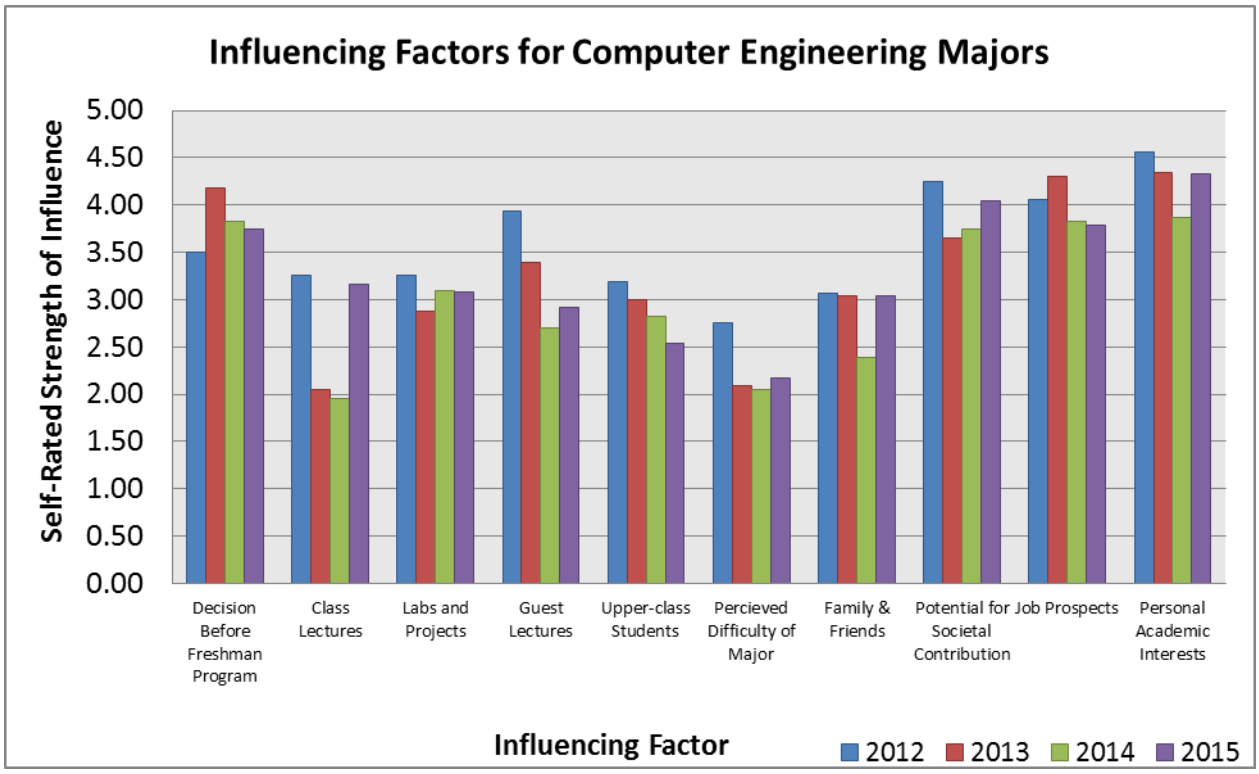

Figure 4. Factor ratings for "CoE" students.

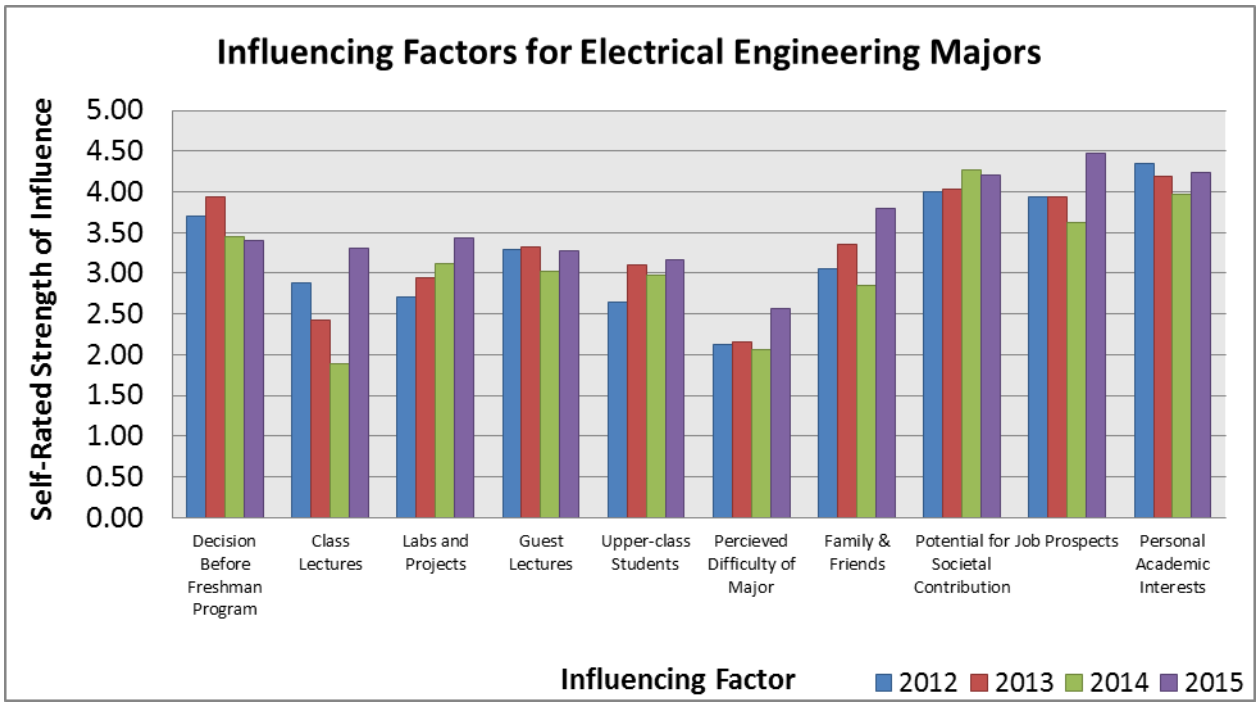

Figure 5. Factor ratings for "EE" students.

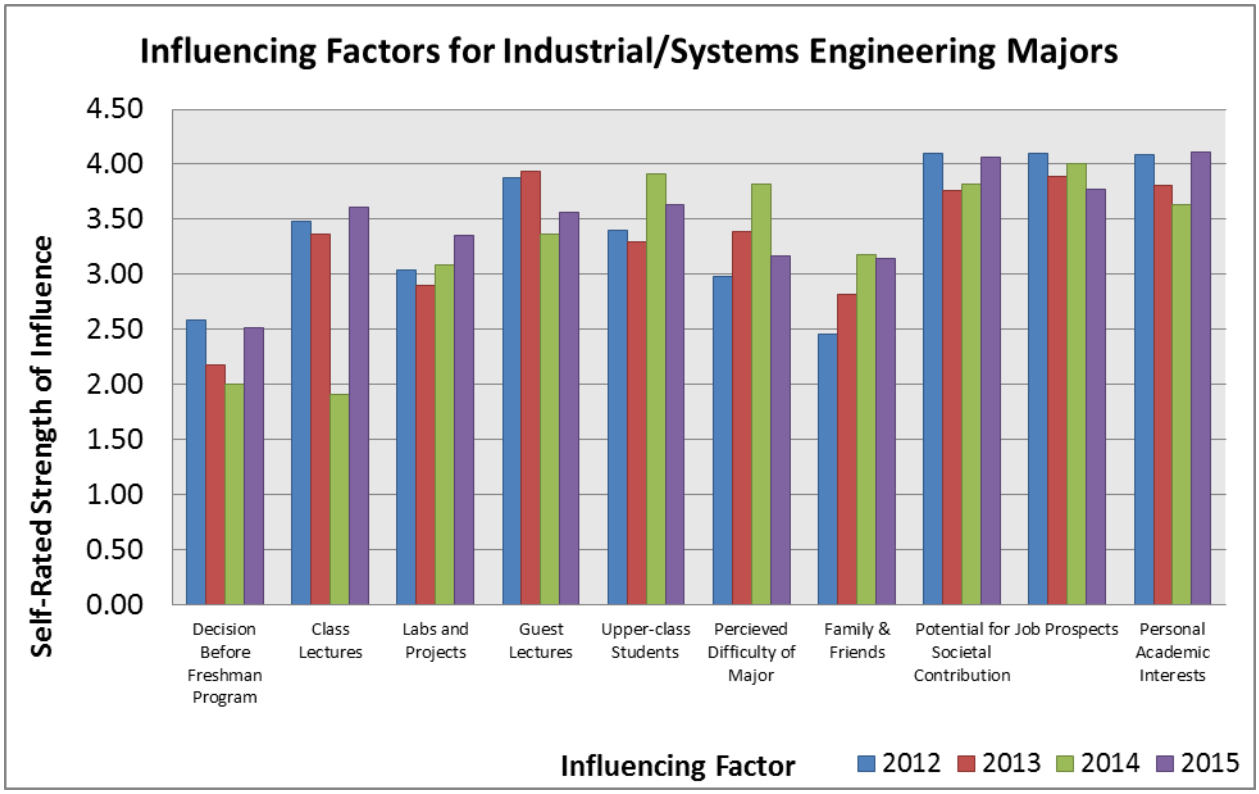

Figure 6. Factor ratings for "ISE" students.

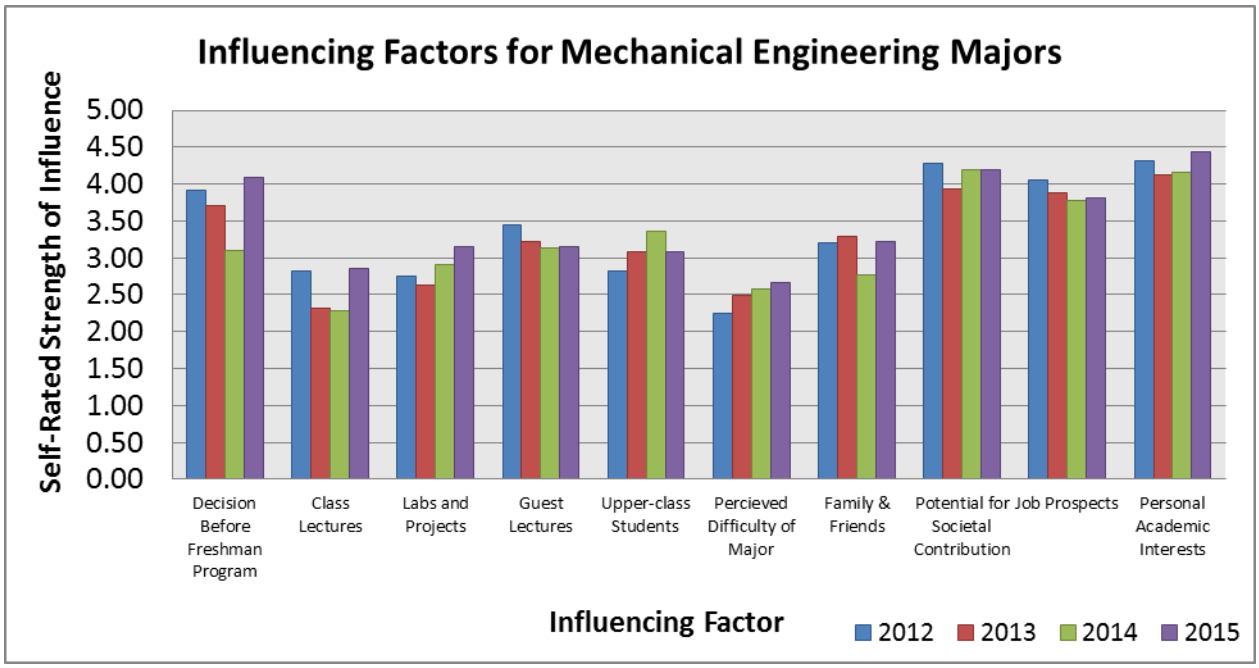

Figure 7. Factor ratings for "ME" students.

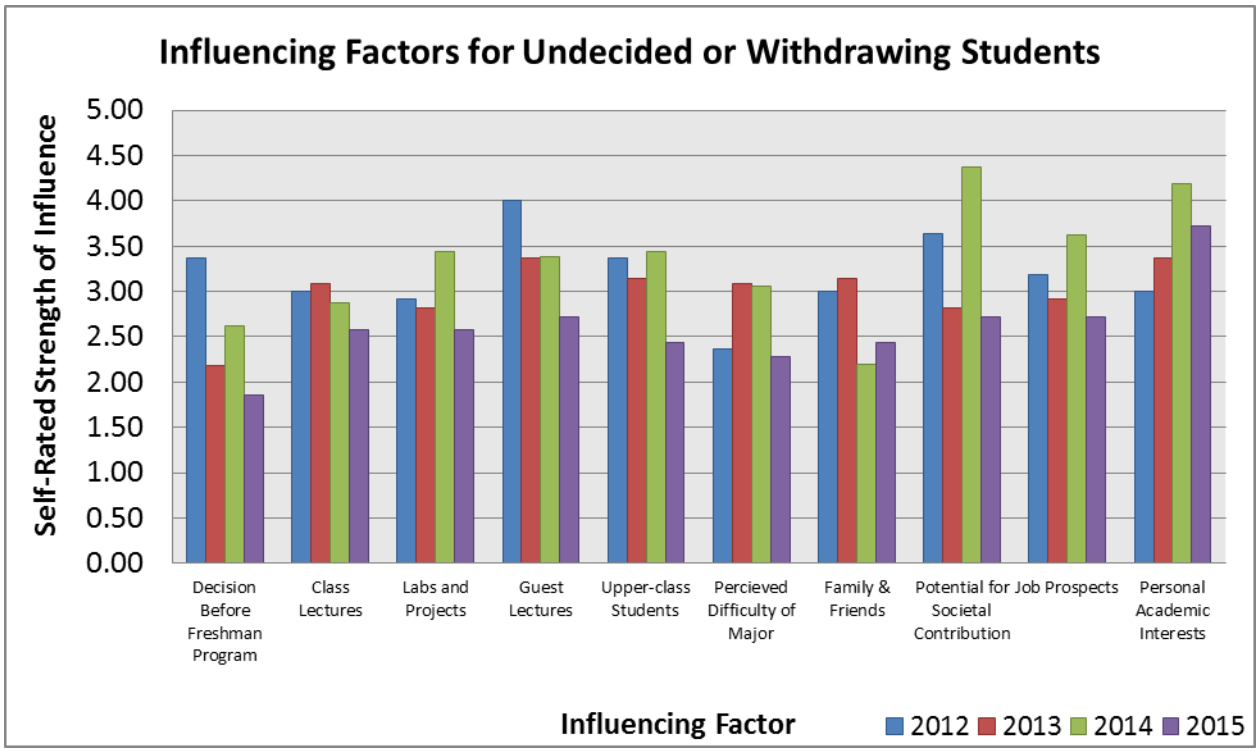

Figure 8. Factor ratings for "Other" students.

The following observations relate to the subgroups of students according to intended major. The bioengineering students (BE) believed the "Labs and Projects" and "Family and Friends" factors were significant in helping them choose a major, and they did not rate "Job Prospects" as highly as the "All" group of students. The computer engineering (CoE) students believe "Class Lectures" were an important factor in years 1 and 4 of the study, but did not think "Class Lectures" were an important factor in years 2 and 3. The electrical engineering (EE) students rated the "Perceived Difficulty of Major" factor as even less important than the low rating given by the "All" group of students. The industrial/systems engineering (ISE) students had a low rating for the "Decision Before Freshman Program" factor and high ratings for nearly all the other factors, except "Family and Friends." Not surprisingly, the more "open minded" students who ultimately chose ISE appeared to be most influenced by the content of the WTSN courses. The mechanical engineering (ME) students rated the factors most similarly to the "All" group of students, which is not surprising, since ME students were the largest subgroup and thus had the most influence on the "All" results. Also not surprisingly, the "Undecided or Withdrawing" students results are least like the "All" results and appear to be most random in their evaluation of factors; however, at least in some years the "Potential for Societal Contributions" and "Personal Academic Interests" may have persuaded these students to choose a major outside of engineering.

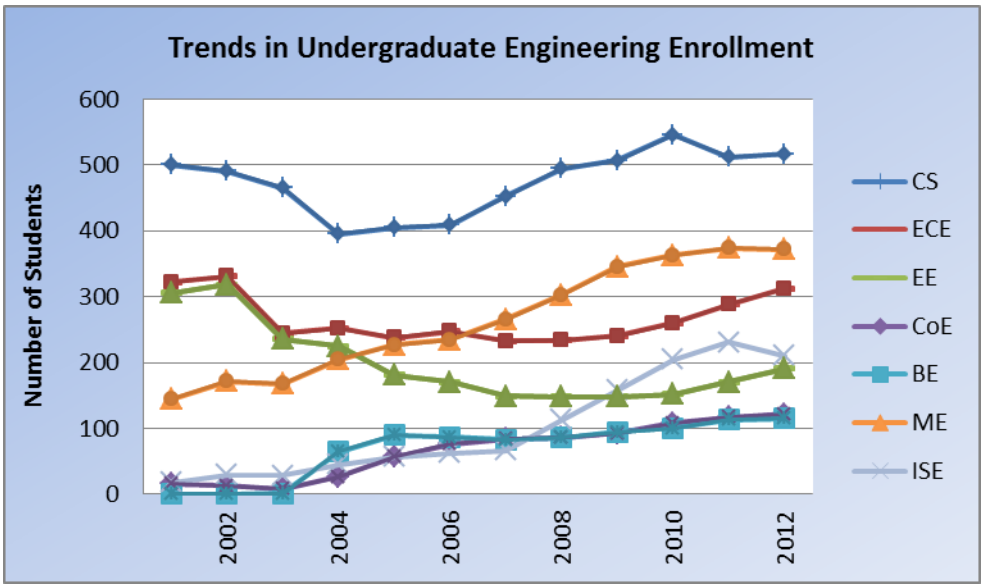

Figure 9. Trends in undergraduate engineering and computer science enrollments at Binghamton University from 2001 to 2012.

Local STEM and engineering enrollments (see Figure 9 for Binghamton University undergraduate engineering and computer science enrollment trends, and Figure 10 for national undergraduate engineering and computer science enrollment trends) often mirror national and even international trends, suggesting factors considerably beyond the local university influence are very important for students in their decision making. For example, both Binghamton

University enrollments and national engineering averages in various majors indicate much more student interest in mechanical engineering than in electrical and computer engineering. Ten years ago the reverse was true. It seems likely that larger factors, beyond the control of a freshman engineering course, must be having an effect on student attitudes and interests.

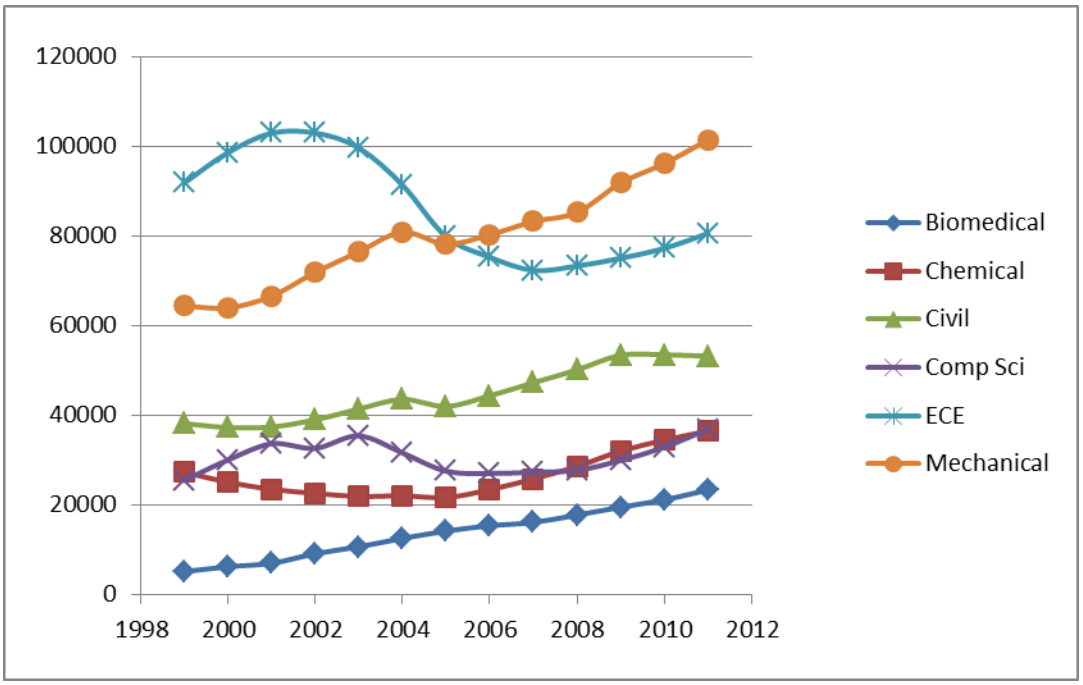

Figure 10. National trends in undergraduate engineering and computer science enrollments 1999-2011.

Summary

We continue to believe that a common first year experience for engineering students, allowing students to choose a specific engineering major near the end of that first year, is a sound academic practice. However, many of these officially "undecided" students have already decided on a major, and are less receptive to considering other choices. The factors that can be directly controlled in a freshman engineering class (such as "Class Lectures" and "Labs and Projects") are overall far less significant than factors that extend far beyond the freshman engineering lab and classroom -- such as "Potential for Societal Contribution," "Perceived Job Prospects," and "Personal Academic Interests.

In terms of specific actions that could be taken to possibly influence students selections of majors, one method that emerges is to point out the societal contributions associated with a particular major. For example, in discussions with students, many perceive energy issues as a major societal concern and also believe they have the best chance to contribute in this area with a mechanical engineering background, despite the fact that a larger and larger percentage of energy usage uses the medium of electrical energy as an intermediate step. Even the transportation

sector is becoming more and more "electrified." Similarly, many students believe that bioengineering is most related to health care (of great societal benefit) despite the fact that much medical instrumentation is designed by electrical and computer engineers, and health care system efficiency is often worked on by industrial and system engineers. Another point that might influence some students is an in depth discussion of job prospects in general and specific examples of types of jobs available in each major.

At Binghamton University, our main goal in presentations to freshmen about each major is not, however, to sway them toward any particular major, but rather present them with information to make the most informed decision that can make, and hopefully lead to a satisfying and rewarding career. However, likely the most important overall recommendation from this study (as well as others), is that the actions mentioned above should be taken well before students enter a university, in visits to local high schools and/or middle and grammar schools. It seems likely students have a general idea of what career paths are important for society and have good job prospects, long before entering college.

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