

# Recruiting and Retaining Students into Engineering Sciences: the Role of Introductory Courses

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**Abstract** -The Harvard School of Engineering and Applied Sciences, HSEAS, offers two undergraduate degrees in engineering sciences, an AB degree (bachelors of arts) and an ABET accredited SB degree (bachelors of science). The AB degree requires 14-16 courses compared to the 20 courses a student must take to complete the SB degree. In addition to requiring fewer courses there is a slightly different structure to the course requirements. For both degrees, a student must choose an area of specialization. These include biomedical sciences, electrical engineering and computer science, environmental sciences and mechanical and material science. Students do not declare a concentration (major) until the middle of the second year. Prior to declaring a concentration students are taking courses to determine if they would like to pursue a particular path. There are several types of courses which a first or second year student could take which would introduce him or her to engineering; freshmen seminars, introductory to engineering courses which are typically broad introductions to an area such as electrical engineering and courses dedicated to specific content area, e.g. circuits. Freshmen seminars do not count toward the degree requirements. The introductory courses and the content area courses can be used as electives but they are not necessarily required. This depends on the area of specialization. This paper investigates whether the first course in engineering determines if a student completes the AB or SB degree and if students are more likely to pursue and area if they have taken the introductory course. This information is determined by examining the transcripts for the class of 2007, 2008 and 2009. Additionally, the introductory courses are examined to determine if they serve as feeders to engineering or as courses for the broader Harvard community.

*Index Terms* – Retention, Introductory courses

## INTRODUCTION

This paper focuses on the interaction between introductory courses in engineering and choosing engineering as a concentration. Courses are not the only aspect of a department which influences a student's

choice in a major (concentration). Both the recruitment process and the advising as well as other aspects will contribute to the decision. Prior to the class of 2010, students declared a concentration at the end of the first year. Since the students considered in this paper are from the classes of 2007, 2008, and 2009 they all declared a concentration at the end of the first year. Of course it is possible to change a concentration after the initial declaration and some students do change. Starting with the class of 2010, students declare a concentration at the end of the third semester (middle of the second year). Since it is believed that by moving the declaration date later in a student's career that there will be fewer students who change concentrations, this paper will not investigate how course selection may influence the change of major process. In order to set the stage for the discussion of courses both the recruitment and early advising will be described.

All undergraduates admitted to Harvard University are admitted to Harvard College through a central admissions process. The college admits approximately 2000 students annually and yields a freshmen class of approximately 1600. Although students are not admitted into a concentration and do not choose one until at least the end of the first year, most students (approximately 98%) specify a broad area of interest such as the physical sciences, engineering, computer science, the social sciences, humanities, fine arts, etc on their application. Table I gives the number of students admitted who expressed an interest in engineering at the time of the application.

## ADVISING AND RECRUITMENT

There are several types of recruitment/advising strategies depending on what stage a student is in the admissions process. The first category of students is those who are interested in Harvard but for whom an admissions decision has yet to be made. This includes both students who have applied and those who are looking at the college. These students are encouraged to look at our undergraduate website (<http://www.seas.harvard.edu/academic/undergradstudy/engineeringsciences/index.html>) and to ask questions of the academic office either in person or by e-mail. Some tour the campus but many do not. The second group of students is those who are accepted but have not yet

chosen to matriculate to Harvard. These students receive a letter from the Dean of Engineering which congratulates them and invites them to a special web chat for students interested in engineering and applied sciences and the engineering open house which is held during the visiting weekend sponsored by the office of admissions. The web chat is held during the week from 9-11 pm. The timing is design to maximize the possibility that a student from the west coast will be available. The chat consists of two to three faculty members, two to three current students, the assistant dean for academic programs, and the communications director for the school of engineering and applied sciences as well as the admitted students. There has been no formal evaluation of this program which has existed for the last two years. It is thought that it is successful because about 75 admitted students participate each year, and the “conversation is lively”. Both years students have participated from foreign countries such as Mauritius and Kuwait. Since there is a transcript of this event it also helps to document the most frequently asked questions. This in turn helps inform the web site. Approximately half of all of the admitted students are called by a faculty member. Again the intention here is to provide an opportunity for the student to ask questions about our program. As can be seen from Table I, from 65% to 71% of the students who expressed an interested in engineering matriculated to Harvard College. It appears from these numbers that the number of students entering Harvard College who are interested in engineering is declining. This is an artifact of this three year sample. In fact the number entering the class of 2011 is 196 and the matriculation rate is also improving. For the class of 2010 it is 72%.

The group of matriculated students forms the third group of students namely those interested in engineering in the first year. At this point the process is no longer one of recruitment but rather of academic advising. Prior to the start of the academic year, first year students receive a letter from the assistant dean for academic programs. This letter invites them to advising sessions offered in the first week of the term. These are both group and individual sessions. The intention here is to help students determine the appropriate level of math, physics and chemistry. There are several introductory courses in these areas. Not all of which are accepted for the engineering sciences degree. Students, who would like to keep engineering as an option, need to know which courses they should consider. This is also an opportunity to discuss engineering courses which are appropriate for students in the first and second years. For the students in the classes of 2007-2009, there are three introductory courses; ES 6, Environmental Science and Technology, ES 50 Introduction to Electrical Engineering and ES 51, Computer Aided Machine Design. None of these courses are required for the engineering sciences degree; however, all three of them can be used towards the degree. Additionally the first two, ES 6 and ES 50, satisfy a core science requirement.

The core is the general education program for all Harvard undergraduates.

The fourth and final group of student is those who selected the concentration. As one can see from table I, the number of students who choose engineering as a concentration is significantly smaller then the number of students who expressed an interest at the time of application. On average, 1/3 of the students who entered with an expressed interest in engineering choose to concentrate in it. It is not unusual for students to leave engineering after the first year. Table II [1] shows the number of students in the United States in each grade studying engineering for four different calendar years. If one compares the number of second year students in 2001 with the first year students in 2000, one will conclude that 77% of the first year students continued to the second year. In 2002 there are more third

TABLE I  
ENGINEERING SCIENCES

Class	2007	2008	2009
Admitted	197	183	164
Matriculated	140	123	106
Percent matriculating	71	67	65
Choose concentration	41	46	31
Percentage matriculated choosing concentration	29	37	29

year students then there were second year students in 2001 so some students must have returned from leaves of absences (both voluntary and involuntary) and some students may have entered engineering programs. Consistently the largest change in the number of students is between the first and the second year. The number of students who persist is 77% which is more then double the number of students who persist in engineering at Harvard. Some of these students have undoubtedly changed their mind prior to admission since the number of students choosing introductory courses in engineering is on average about 30. (See table III)

The School of Engineering and Applied Sciences would like to see the percentage of students choosing engineering increase. There are several initiatives in place to try to improve this number. Broadly these fall into two strategies, academic advising and curriculum reform. This paper is focusing on the curriculum discussions.

Once students choose engineering they stay with the concentration. The current numbers for each class are given in Table IV. These numbers compare favorably with the number of students who choose the concentration at the declaration time.

TABLE II  
THE NUMBER OF STUDENTS PURSUING ENGINEERING IN THE UNITED STATES

	2000	2001	2002	2003
Freshmen ( first year)	101,773	106,825	107,086	103,834
Sophomore ( second year)	76,700	78,348	81,854	82,542
Junior (Third year)	74,055	76,938	79,806	80,703
Senior (fourth) and fifth year	100,584	105,843	114,363	117,533

TABLE III  
ENROLLMENT IN INTRODUCTORY COURSES

Course	03-04	04-05	05-06	06-07
ES 6	30	26	28	44
ES 50	28	28	29	38
ES 51	17	28	13	20

TABLE IV  
CURRENT ENROLLMENT

	AB	SB
2007	18	21
2008	15	21
2009	14	18

## DESCRIPTION OF DEGREE REQUIREMENTS

All undergraduate degrees at Harvard consist of 32 semester courses. The ABET accredited bachelors of science (S.B.) degree in engineering sciences consists of 20 courses and the bachelor of arts degree (A.B.) degree is completed with between 14-16 courses depending on where a student places in mathematics.

There are five specializations in the A.B. program. They are biomedical sciences and engineering (BSE), electrical engineering and computer science (EECS), engineering physics (EP), environmental sciences and engineering (ESE) and mechanical and material science and engineering (MMSE). Four of these are also specializations in the S.B. program: biomedical sciences and engineering, electrical engineering and computer science, environmental sciences and engineering and mechanical and material science and engineering.

The S.B. program consists of two years of math, two semesters of physics, two semesters of chemistry, a computer science course, an electronics course, a mechanics course, an advanced applied math course, a materials course, a probability and statistics course, and two courses in design. The remaining 4 courses are determined by the specialization. Students who place into the second year of calculus take additional engineering electives so that the total number of courses is always 20. All students in the A.B. program complete the second year of calculus, one year of physics and one semester of introductory computer science. Some

students need to take the first year of calculus. The remaining 9 courses are determined by the specialization pursued. [2] There are several differences between these two degrees. The three most important are (1) the A.B. degree does not require design, (2) the A.B. program does not have core set of disciplines which all students study, (3) the content areas determine 9 courses in the A.B. and only 4 in the S.B.. The second and third points provide the possibility for the A.B. degree to be a much narrower degree.

## INTRODUCTORY COURSES

As mentioned above the relevant introductory courses for the students in the classes from 2007 - 2009 are the following: ES 6, Environmental Science and Technology; ES 50, Introduction to Electrical Engineering and ES 51, Computer Aided Machine Design. ES 51 is offered in the fall and ES 6 and ES 50 are offered in the spring. As one can see from Table III, the number of students taking these introductory courses is quite small. Not all of these students intend to concentrate in engineering sciences. In fact the percentage of concentrators who takes an introductory course is 44, 60, 29 for the AB degree for the classes of 2007, 2008 and 2009 respectively and 29, 19, 17 for the SB degree for the same years (See Table V). On average, less than half of all of the concentrators take one of the introductory courses. It is less common for the SB students to take these courses than it is for the AB student. Students in the SB program have very little room for extra electives. This may explain why it is less common to take an introductory course.

TABLE V  
PERCENTAGE OF STUDENTS TAKING INTRODUCTORY COURSE IN FIRST YEAR

	AB	SB
2007	44	29
2008	60	19
2009	29	17

About half of the concentrators who take the introductory course do not take it in the area in which they specialize. Two reasons may account for this. One, students often do not know much about the areas prior to taking the course so this course may help them choose between areas. Two, until the 2006-2007 academic year there was no introductory course in bioengineering.. This specialization accounts for 35-50 percent of the students. Many of these students took either the electrical or mechanical introductory course. It is more common to take the introductory course in the area of specialization in the SB program. (See table VI)

TABLE VI  
FRACTION OF STUDENTS WHO TAKE INTRODUCTORY COURSE IN AREA OF SPECIALIZATION

	AB	SB
2007	5/8	4/6

2008	2/9	4/4
2009	2/4	5/5

In order to understand the enrollment in these introductory courses we will look in detail at the classes for the 2005-2006 year. In this year ES 6, the intro to environmental engineering, had 3 first year students out of a class of 28. Two of these students are currently engineering sciences concentrator and one is in economics. The intro mechanical class, ES 51, also had three first year students. The total enrollment was 13. One of the three first year students is currently in engineering sciences, one is in applied math and one is in economics. The intro electrical course, ES 50, had an enrollment of 29. There were 11 first year students. One student has withdrawn from the university, two are studying physics, one is in applied math, one in economics, one in computer science and 5 are in engineering sciences.

Even though the faculty considers these first year courses, they all have students from all years. (See table VII) It is true that the majority of students come from the first two years, so one can think of them as primarily introductory courses. However, ES 6 has a healthy number of fourth year students. This is most likely due to the fact that it satisfies a core requirement. ES 50 currently satisfies a core requirement but it did not for the year we are examining.

TABLE VII  
BREAKDOWN BY YEAR OF STUDENTS IN INTRODUCTORY COURSES

	ES 6	ES 50	ES 51
First Year	3	11	3
Second Year	13	10	5
Third Year	5	2	3
Fourth Year	7	5	1

It should be noted that the enrollments in ES 6 and ES 50 have increased significantly this year. Table III gives the enrollment for these classes for the last four years. Given that both of these are now core courses, this increase in enrollment may not translate into an increase in the interest in the engineering sciences concentration. The first year students in these classes do not have to declare a concentration until next year so it will be some time until the effect of the increased enrollment will be known.

It has been shown that these courses serve as both introductions to the discipline for students who are interested in engineering and as general education requirements for students who are not concentrating in a science.

## CONCLUSIONS

This paper examines the role of three introductory courses in the recruitment and retention of students interested in engineering sciences at Harvard University.

Although these courses were designed to attract students into engineering, only half of the students concentrating in engineering take one of these introductory courses. They are not required. The majority of students who take these courses do not concentrate in engineering sciences and they are taking the course after they have chosen a concentration. The number of second through fourth year students is larger than the number of first year students. These courses are well reviewed and they have healthy enrollments. That said they are not currently serving as a means to recruit students into engineering. This realization has led to a discussion on the role of introductory engineering courses and the possible creation of a required introductory course for the concentration. This new course would introduce several broad areas of engineering and would discuss the role of engineering in society. It is hoped that this new course would excite more students to choose engineering sciences as a concentration. :

## ACKNOWLEDGMENT

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