

Where Will They Come From?

Increasing the number of engineering graduates: a testable model to suggest strategies and options

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What follows:

A model for testing probable impact of State and OPAS interventions in K-12 to increase the production of new engineering graduates

When designing or optimizing a system, a parametric model provides the ability to confirm understanding of the interactions within the system and the overall transfer function. A variety of OUS, College Board and other data were used to create the following simplified model of the Oregon University System engineering and computer science pipeline for students who enter the system directly from high school with the intent to obtain a 4 year (BS) degree. This model appears to approximately account for about the degree production in the OUS in these fields. There are a number of factors not explicitly included in this model: adult returning students, non-resident alien students, Oregon residents returning from out-of-state or private schools, and out-of-state residents. Perhaps fortuitously, the model still seems to be reasonably predictive of OUS engineering and CS degree production.

The model in figure 1 has been intentionally kept simple enough to utilize real and available data to establish the parametric model.

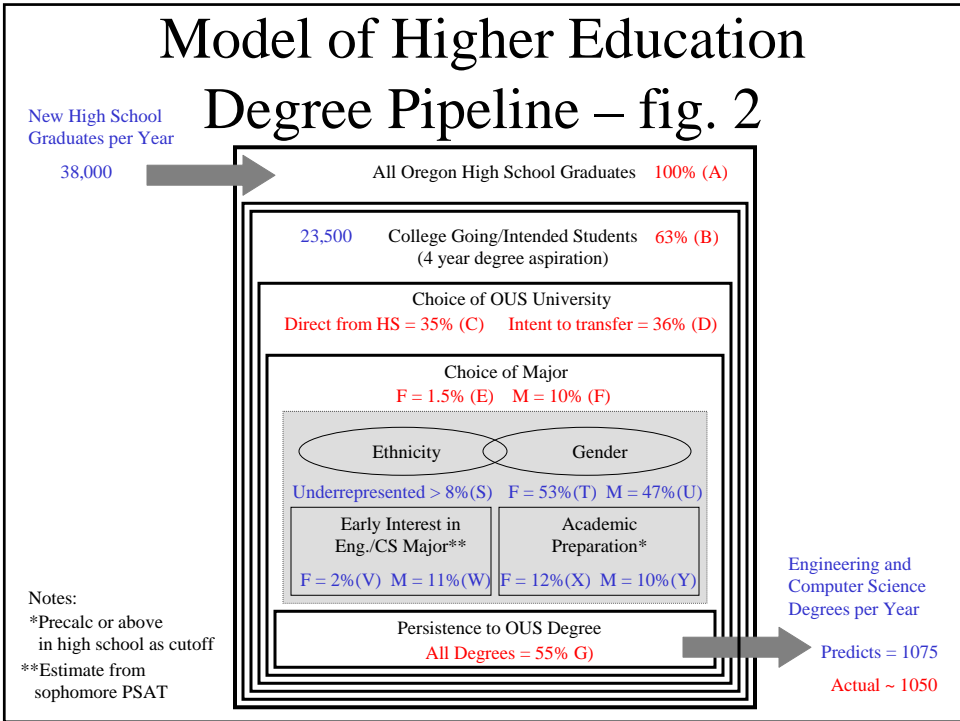
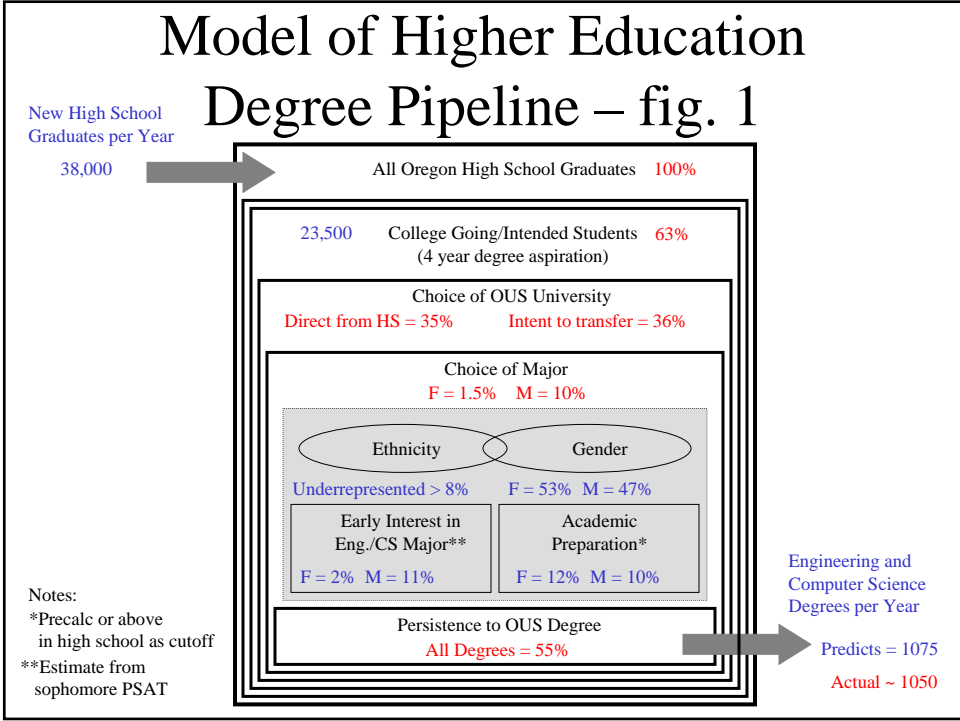
The transfer function for this model is given by the following, where the parameters are the letter designations for the model percentages, as shown in figure 2:

$$\text{Predicted Engineering and CS graduates} = (\text{New High School Graduates}) * A * B * (C+D) * (E+F) * G$$

Substituting from the model we have:

$$\begin{aligned} \text{Predicted Engineering and CS graduates} &= 38,000 * 1 * .63 * (.35 + .36) * (.015 + .10) * .55 \\ &= 1075 \text{ degrees awarded} \end{aligned}$$

The following slides walk through the use of this model to explore implications for the OPAS goals and strategies and to suggest areas for potential tradeoffs or incremental focus.



Parameter A: Number of High School Graduates

The model is normalized to 100% of the total high school graduates. As such, the number of degrees produced is directly proportional to the new high school graduates per year. Projected demographics, as shown in the following slide of OUS projections, indicate the high school student population will probably reach a peak this year or next and then decline slightly (2.5%) in the next few years.

If current high school graduation rates are unchanged, the number of high school graduates will not contribute to growth in degree production and will eventually contribute a small contraction as the current maximum works its way through the OUS system.

However, Oregon is a 3rd quartile performer in the percentage of high school graduates nationally, so improvement in high school graduation rates should be a goal, to which OPAS may be able to contribute. The official Oregon high school graduation rate is about 80% and is less than 70% for all underrepresented groups.

Goal: Improvement in the range of 10% seems possible.

- General implication:
1. K-12 drop out reduction programs
 2. Special K-12 attention to underrepresented dropout reduction
- OPAS implication:
1. Focus on rigorous and relevant pre-engineering experiences in class and OST (pre-engineering CTE, PLTW, OST engineering, etc.)

Parameter B: Oregon College Going Rate

Oregon's college going rate consists of two components. OUS estimates that 40% of high school graduates will enter a 4 year college or university. An additional 23% will enter an Oregon community colleges with the intent to transfer to a 4 year university. The model treats all these students equivalently as College Going/Intended Students for a total of 63%. This model does not consider as "college going" those students (~10%) who enter 2 year colleges with the goal of a terminal 2 year degree. Therefore 38% of Oregon high school graduates are not college going and are potential candidates for increasing the 4 year degree college going rate.

Oregon's college degree production rate (degrees conferred/1000 18-24 year olds) is slightly below the US mean. State rates vary widely on this NSF S&E 2008 indicator, but improvement is certainly possible since a number of states have achieved much higher levels. It is likely that Oregon's current rate is influenced by many variables including demographics, level of K-12 preparation, affordability, and aspiration. Assuming the State continues to address these, especially affordability and preparation, it is a reasonable to target improvement in the College Going Rate as a realistic goal.

Goal: Improvement in the range of 10% seems possible.

- General implication:
1. Implementation of new STEM graduation requirements should enhance preparation
 2. Additional State and private efforts required to further reduce the barriers to affordability
- OPAS Implications:
1. Engaging in-class and OST programs support academic success and development of college going aspirations
 2. Focus on at risk TAG students for college going encouragement and assistance

Parameters C and D: Choice of an OUS University

Currently about 35% of Oregon college going high school graduates matriculate directly into an OUS university and an additional 36% matriculate at a community college with the expectation of transferring to an OUS institution for a 4 year degree, for a total of 71% as shown in figure 1.

This number reflects the central, and even dominant, role of public higher education in Oregon. Preserving this high "university of choice" level is probably a realistic goal and will require continued improvements and expansion of the university and community college systems.

Goal: Preserve current high preference of college going high school students for OUS institutions.

- General Implications:
1. State must continue to invest in improvement and expansion of universities ("top tier" focus) and community colleges
 2. Maintain and improve communications with families and counselors to make OUS the higher education partner of choice
- OPAS Implications:
1. Effective communications with students, parents, and counselors
 2. Work with OUS, community colleges and high schools to align curriculum for smooth transition, with opportunities for advanced placement wherever possible, to maintain "school of choice" advantages

Parameters E and F: Choice of Major Field of Study

Choice of major is the most critical area in the model since it is the area in which the largest attrition of potential engineering and computer science degree recipients occurs.

Furthermore, it is the area in which the greatest disparities become apparent by under-representation of gender and ethnic/race groups.

The combined impact is that only 12% of students in the OUS system choose to major in engineering or computer science fields. There are many factors that influence this number and some of them are commented on below:

1. Under-representation of ethnic/racial group: Several groups are consistently under-represented in the Oregon college going population. While some progress is being made, these groups are still represented in the OUS at about 50% of their proportion of the State's population. In engineering and computer science, the level of under-representation is dramatically more severe, probably closer 10% of the proportion of the total population. Therefore engineering and computer science face a dual challenge: a. Low numbers of under-represented students in the OUS system; and b. Low selection of engineering and computer science by members of these groups. These under-represented groups currently comprise about 8% of the OUS population and a roughly 2x opportunity exists to increase this to achieve proportional representation. Obstacles specific to engineering and CS include low familiarity with and aspiration to these fields and low preparation in the critical gateways of math and science.

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Parameters E and F: Choice of Major Field of Study – cont'd

2. Gender: Young women choose engineering and computer science as field of study at less than one-fifth the rate of young men, and given the 53% female composition of college going students, this would appear to be the largest opportunity to increase the number of engineering and CS graduates. Exact data for choice of these majors by women in Oregon was not available, but it appears to be ~1.5% of OUS bound students vs. 10% for men. It is apparent from figure 1 that academic preparation, once assumed to be a key limiting factor, is no longer an adequate explanation since young women are now prepared in math and science at levels comparable to young men. Reasons often cited for the persistent low, and possibly dropping, rate of female participation include: a. lack of interest in the intrinsic content and work in these fields; b. male "hijacking" of the education culture in these fields in ways hostile to participation by young women; c. a work environment in these fields that is not perceived as supportive of women's success, aspirations or desired lifestyle. It is likely that significant change in female participation will only occur if these fundamental obstacles are addressed rather than by changes within the K-12 system alone. This is not simply a matter of "marketing" – the women may, in fact, have correct understandings and be making completely rational choices. It is unclear whether there is sufficient motivation or will in industry and the universities to make more than superficial change. NSF appears to have significantly reduced funding in this area. Without such fundamental change, it is likely that the OPAS K-12 initiatives will be limited to marginal improvement in this area. Perhaps a very aggressive goal would be to achieve a 3% field of study choice level for young women.

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Parameters E and F: Choice of Major Field of Study – cont'd

3. Academic preparation, especially in math and science, is recognized as a "gate keeper" pre-requisite for success in engineering and CS at the college level. For purposes of this model, a simple and accessible indicator was chosen as a proxy for academic preparation. The indicator is the fraction of students who leave high school have taken math through pre-calculus. This was chosen intuitively based on the indication from university professors that students who arrive in college "calculus ready" are more likely to persist to a degree. There are indications that achievement in this area is gradually improving in Oregon and nationally as a result of K-12 school reform. Oregon's new math and science high school graduation requirements are intended to contribute to further to improvements in math and science preparation. It is interesting to note that this metric indicates that about 20% (10% of total students) of men graduating from high school meet the pre-calculus level of preparation. This level, perhaps fortuitously, is about the same as the fraction of men who actually choose to major in engineering and CS as shown in the model. In contrast, for women the level of preparation is 12% while the level of choosing these majors is only around 1.5%. Therefore the level of preparation may impose a ceiling (men), but other factors may dominate in the actual choice (women). The implication is that focus on improving the academic preparation of men and women may increase the number of students choosing these majors and improved academic preparation may be a dominant factor for increasing the number of men.

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Parameters E and F: Choice of Major Field of Study – cont'd

4. Some limited data on the stage at which major field of study is selected is provided by the SAT and PSAT tests which are given to primarily college bound students as sophomores, juniors, or seniors in high school. These students indicate their intended field of major. It is interesting how early, and stable, these indications are. It appears that by the sophomore year already 12.2% of these students indicate an intent to major in engineering or computer science and this intent drops to about 11% by the senior year in high school. This has tremendous implications for when students are making critical education and career decisions. A closer look at this limited data set has some additional interesting features as shown in the table in the following slide:
- a. The fraction of students expressing an intent for engineering technology plummets from 2.4% in the sophomore year to only 0.6% for seniors;
 - b. Computer science intent rises sharply from 1.1% for sophomores to 2.7% for seniors
 - c. Engineering drops moderately from 8.7% to 7.7% during this period.
 - d. Preferences for both girls and boys seem amazingly stable between the sophomore and junior years even though the sample size doubled due to more PSAT test taking by juniors. If it is correct that nearly all of the above changes occur between the junior and senior year, it may indicate the critical nature of the college admission process (late junior, early senior year) in making actual field of study choice.

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Parameters E and F: Choice of Major Field of Study – cont'd

Summary: Choice of major among college going students is a result of many factors including preparation, perceived attractiveness of career compared to students' other options, exposure to these fields at formative decision making periods in students life, and perceived social fit. Opportunities exist for improving the attractiveness and accessibility of engineering and computer science including: increased early exposure (prior to HS sophomore year at least), increased engagement with these fields through the critical time when the major is selected in the senior year in HS, stronger academic preparation in math and science, and change in cultural and social attractiveness to women and underrepresented ethnic/race groups, which may be difficult without structural changes in both the university programs and industry.

- Goals:
1. Maintain, or modestly expand, the choice rate among the core majority male demographic as the college going rate is increased by focusing on improved academic preparation and increased opportunities to maintain or increase early interest. A 20% improvement may be achievable;
 2. Incrementally increase the component of women choosing these fields by focusing on increased exposure and engagement, recognizing that further progress will be paced by the rate of change in social aspects of the fields and academic preparation is not the primary constraint. A 2x increase is aggressive, but may be achievable.
 3. Significantly increase the component of under-represented students by focusing on high academic potential (even if underachieving) students in these groups. An increase of 2-5X may be achievable, very significant even though the starting base numbers are small.

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Parameters E and F: Choice of Major Field of Study – cont'd

General Implications:

1. Continue State focus on increased math and science standards and achievement, especially through the critical pre-calculus level;
2. Continue State focus on academic persistence and success for under-represented ethnic/race groups and increase focus on TAG program for academically talented, even if underperforming, students in these groups

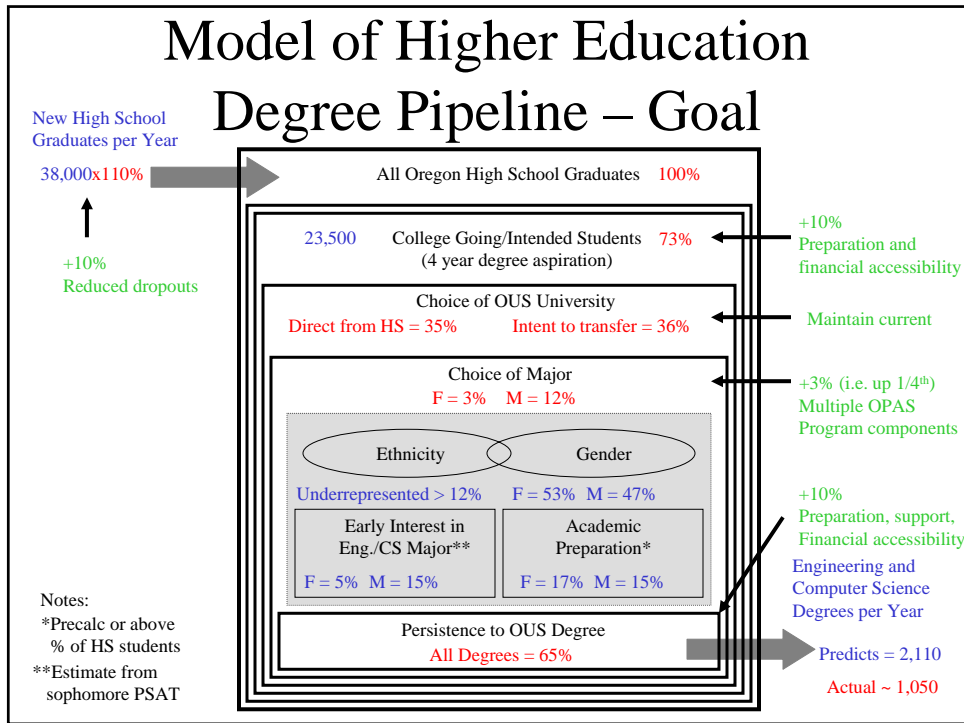
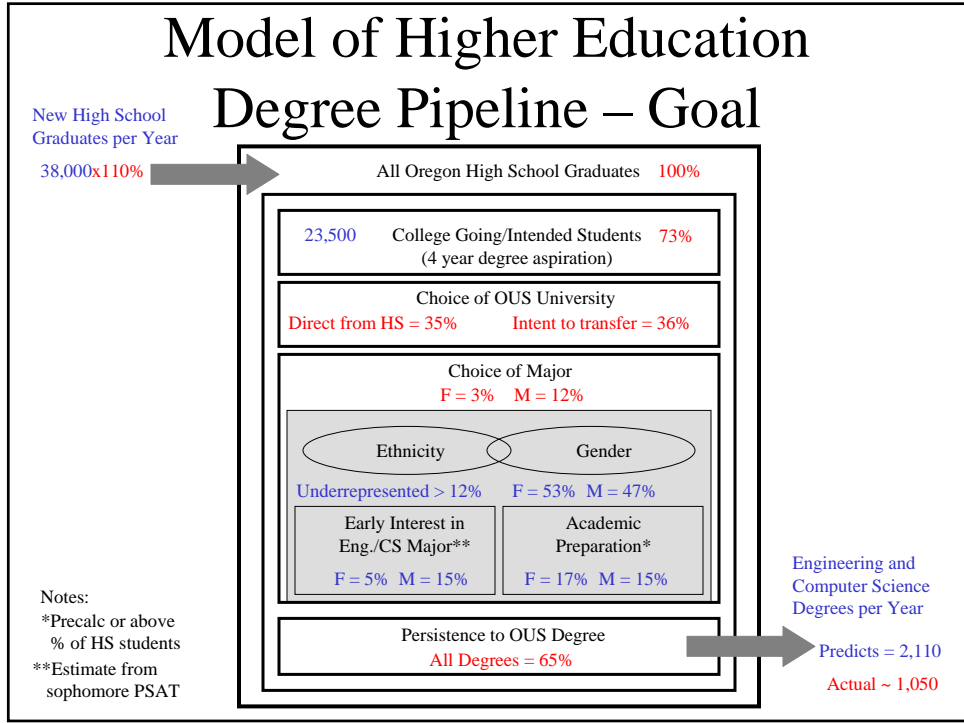
OPAS Implications:

1. Support inclusion of engaging engineering and CS content in State math and science programs, with graduation credit, university transfer credit, and advance placement where appropriate;
2. Increase opportunities for students to experience and identify with engineering and computer science careers prior to the point at which they form individual intentions, which apparently occurs prior to their sophomore year in high school;
3. Increase the opportunities for students to continue to engage in engineering and computer science throughout high school to maintain, and increase, their level of early interest;
4. Support, or create, intensive engineering and computer science experiences for academically gifted under-represented ethnic/racial minority group to encourage plans for college going and to develop interest in engineering and CS as majors.
5. Take special steps to achieve inclusion of girls in all the above, including "girls only" versions if deemed helpful;
6. Advocate for larger scale cultural change at the university and industry levels to make these fields truly career and life friendly for women.

Persistence to OUS Degree

Increasing Oregon's relatively low rate of persistence to a degree (55%) is a major opportunity and a subject of on-going focus by both the OUS system and the legislature. As such, it is largely beyond the purview of the OPAS initiative, although OPAS initiatives to better prepare students will support an increase in the rate of persistence. OPAS may also wish to direct attention to the transition stage between high school and university, especially for those students who have high academic potential but who may be at increased risk for reasons such as weak academic preparation (ex: coming from a low performing high school) or lack of preparation for the cultural demands of university study. The OUS should target this group of students for participation, and associated financial assistance to enable participation, in academic "bridge" programs and mentoring, preferably beginning in the summer before OUS matriculation or before.

Goal: Increase the freshman retention rate in engineering and computer science for these students by a significant increment. The OUS campuses should each be asked to assess this opportunity, set goals, and create or expand the necessary programs. The OUS should include funding for these programs in the university budgets as an incentive to give this need serious priority.



Summary of Impact

OPAS and Related Impacts are due to proposed OPAS initiatives in conjunctions with projects and investments being planned by ODE, local school districts, OUS, and community colleges.

Pipeline Sequence	OPAS and Related Impacts	Current		After OPAS and Related Impacts		
		OUS Now	Students	OUS Now	Impacts	Students
New high school graduates			38000			38000
	Drop out reduction				110.0%	41800
College going rate		63.0%	23940	63.0%		26334
	Preparation and financial assistance				115.9%	30513
Choice of university		71.0%	16997	71.0%		21664
	Maintain				100.0%	21664
Choice of major		11.5%	1955	11.5%		2491
	K-12 initiatives				130.4%	3250
Persistence to degree		55.0%	1075	55.0%		1787
	Barrier removal				118.2%	2112
Total engineering and CS graduates			1075			2112

Where the graduates could come from?

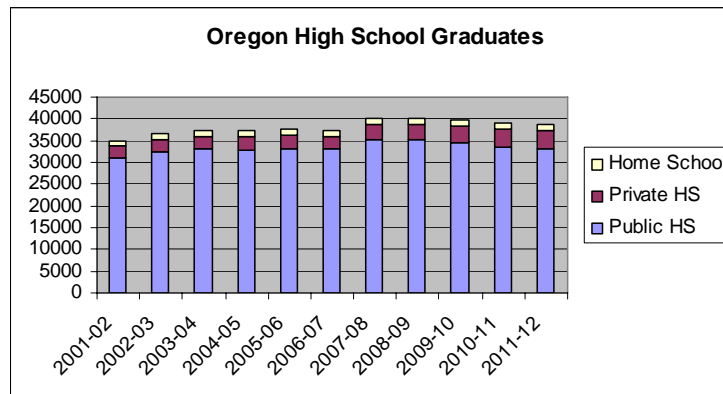
Supporting Data

When Do They Choose?

All Test Takers			
	Seniors	Juniors	Sophomores
Computer Science/IT	2.7	1.2	1.1
Engineering	7.7	8.6	8.7
Engineering Technology	0.6	1.7	2.4
Total	11	11.5	12.2
Girl Seniors Taking SAT			
	Seniors	Juniors	Sophomores
Computer Science/IT	?	0.2	0.2
Engineering	?	2.1	2.1
Engineering Technology	?	0.4	0.4
Boys Seniors Taking SAT			
	Seniors	Juniors	Sophomores
Computer Science/IT	?	2.4	2.3
Engineering	?	16.5	16.4
Engineering Technology	?	3.4	4.7

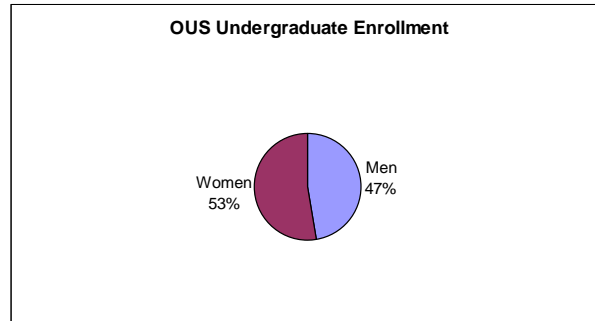
Student Populations					
	Graduating Seniors	4 Year College Seniors	SAT Seniors	PSAT Juniors	PSAT Sophomores
	39,000	15,210	13,546	15,599	6,907

Available Pool



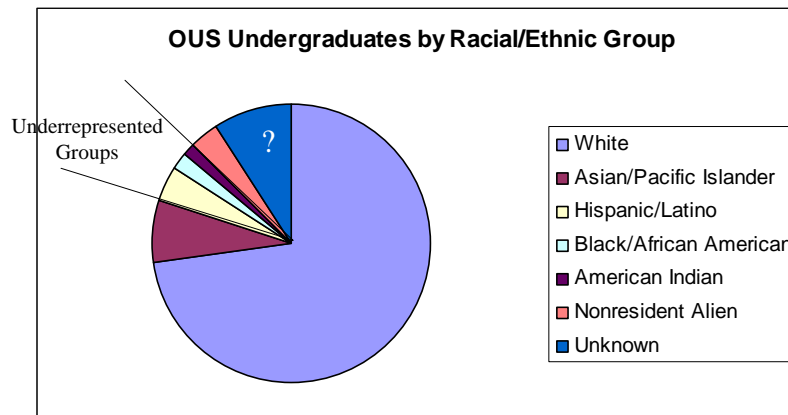
Situation: Growth in number of H.S. graduates will make a modest positive impact (~4%) on number of engineering students.

Gender



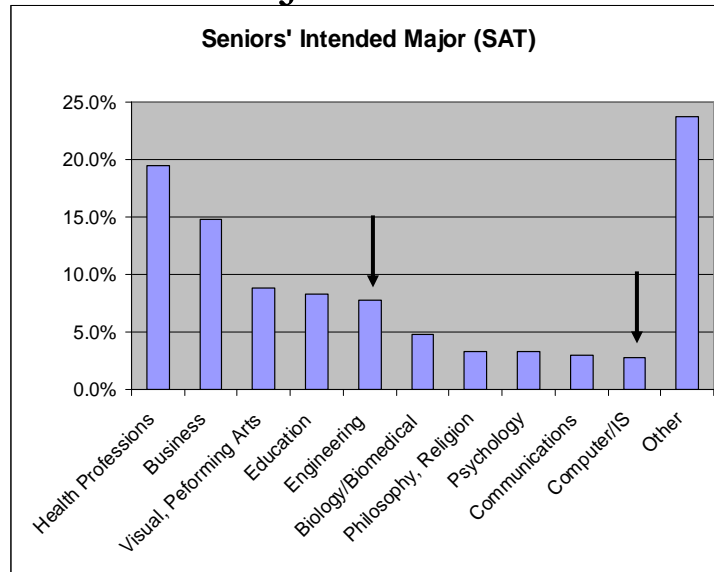
Situation: Tremendous under representation of women in engineering – <20% of engineering students. Historically this has been well recognized and difficult to change. This remains a huge opportunity for growth in engineering students.

Ethnicity



Implications: the groups indicated above are significantly underrepresented in both college going and in engineering fields for those who do go.

Planned Majors as H.S. Seniors



Situation: Top 5 = 59%; Top 10 = 76%. Engineering +CS = 10.4%

Planned Majors as H.S. Seniors

Subject	Per Cent	Subject	Per Cent	Subject	Per Cent
1 Health Professions	19.5%	14 Undecided	2.1%	27 Military Sciences	0.5%
2 Business	14.7%	15 Physical Sciences	1.6%	28 Theology and Vocations	0.5%
3 Visual, Performing Arts	8.8%	16 Legal Professions	1.6%	29 Mechanics and Repair	0.4%
4 Education	8.3%	17 Security	1.5%	30 Family Sciences	0.3%
5 Engineering	7.7%	18 Foreign Language	1.3%	31 Interdisciplinary Studies	0.3%
6 Biology/Biomedical	4.8%	19 History	1.1%	32 Parks, Rec. and Fitness	0.3%
7 Philosophy, Religion	3.3%	20 Agriculture	1.0%	33 Culinary Services	0.2%
8 Psychology	3.3%	21 Liberal Arts	0.9%	34 Transportation, Matl. Moving	0.1%
9 Communications	3.0%	22 Other	0.7%	35 Ethnic/Gender	0.1%
10 Computer/IS	2.7%	23 Natural Res. Conservations	0.6%	36 Construction Trades	0.1%
11 Architecture	2.4%	24 Mathematics	0.6%	37 Library Science	0.0%
12 Social Sciences	2.3%	25 Engineering Tech	0.6%	38 Precision Production	0.0%
13 English	2.2%	26 Public Admin., Soc. Services	0.5%		

College Board SAT data