



D-E Communications - Critical Issues Series

Women in Engineering & Related Fields – Diversity Analysis of Students Earning Bachelor’s Degrees

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The Critical Issues Series (CIS) consists of short, to-the-point documents, each addressing a single identified issue of importance. These documents are intended to stir discussion and/or action within the engineering community. We welcome your feedback via CIS@DedicatedEngineers.org. Copies of all CIS documents are maintained on our website at www.DedicatedEngineers.org.

EXECUTIVE SUMMARY: The gender breakdown of students earning bachelor’s degrees was examined to address a critical, “bottom-line” question: How “gender-diverse” are the graduating baccalaureate classes in Engineering and five closely-related fields (namely: Chemistry, Physics, Math & Statistics, Computer Science, and Engineering Technology) when compared to the diversity seen in the graduating baccalaureate class of all Science & Engineering (S&E) fields combined?

Through this assessment – which involved examining both the most recent data set available (for 2004), as well as historical data (covering 1966-2004) – four of the six fields evaluated (namely: Physics, Computer Science, Engineering, and Engineering Technology) were identified as significant laggards in achieving gender diversity in their graduating baccalaureate classes – collectively, only about one-in-five students earning baccalaureates in these fields were women in 2004, compared to a one-in-two rate seen when considering S&E as a whole. Within Engineering, the sub-disciplines of Electrical and Mechanical Engineering were found to be particularly weak areas where collectively only 14% (about one-in-seven) of baccalaureate-earners were women in 2004 – one-half the 28% level recorded for all other Engineering sub-disciplines combined. Finally, the percentage of female baccalaureate-earners has not significantly increased since 2000 for any of the four fields identified as laggards.

Given such statistics, it is intended that this report will serve as a “call to action” to colleges/universities, relevant professional societies, and other appropriate entities to undertake and/or support new or additional efforts/initiatives specifically focused on increasing the enrollment and retention of women nationwide in undergraduate programs in the fields of Physics, Computer Science, Engineering, and Engineering Technology. In this regard, we propose that aggressive national goals be set at achieving 33% (one-in-three) female baccalaureate-earners in Physics, Computer Science, and Engineering (and 25% [one-in-four] in Engineering Technology) by the year 2020. To achieve such ambitious goals in Engineering, particular focus will need to be placed on the lagging sub-disciplines of Electrical and Mechanical Engineering, given that they collectively account for about one-half of all baccalaureate degrees annually awarded in Engineering.

1. Introduction

In examining the issue of women in Science and Engineering (S&E) and associated diversity issues, there are many possible points of view and corresponding data analyses that can be conducted in various attempts to assess the situation. The analysis reported herein examines the gender breakdown of students earning bachelor’s degrees to address a critical, “bottom-line” question: How “gender-diverse” are the graduating baccalaureate classes in Engineering and five closely-related fields (namely: Chemistry, Physics, Math & Statistics, Computer Science, and Engineering Technology) when compared to the diversity seen in the graduating baccalaureate class of all S&E fields combined?

The rationale for conducting this specific comparative analysis is based on the following two considerations:

- Awarded bachelor’s degrees define the ultimate success of efforts aimed at increasing the diversity of the scientific and engineering professions, given that a bachelor’s degree represents the entry-level educational requirement for both professions.
- By conducting comparisons specifically versus S&E as a whole (as opposed to oft-used comparisons to general population demographics), a particularly useful “yardstick” is employed to measure the diversity achieved within S&E, one enabling identification of leading and lagging fields within S&E.

Through this assessment – which involved examining both the most recent data set available (see Section 2), as well as historical data (see Section 3) – four of the six fields evaluated (namely: Physics, Computer Science, Engineering, and Engineering Technology) were identified as substantially lagging in achieving gender diversity on a par with that seen for S&E as a whole. As such, a “call to action” is put forth (see Section 5), calling upon pertinent parties to undertake and/or support new and additional efforts/initiatives specifically aimed at increasing gender diversity in those four fields, with a long-term goal put forth of achieving 33% female baccalaureate-earners in Physics, Computer Science, and Engineering (and 25% in Engineering Technology) by the year 2020.

2. Data Sources

All data on the gender breakdown of students earning bachelor’s degrees was obtained from the National Science Foundation’s (NSF) WebCASPAR database (located online at <http://webcaspar.nsf.gov>), which contains a large body of statistical data resources regarding science and engineering education at U.S. academic institutions. The specific data set accessed for this effort was the U.S. Department of Education’s National Center for Education Statistics’ (NCES) “IPEDS Completions Survey – Degrees/Awards Conferred (NSF population of institutions).” Both the latest data set available (for 2004) and time series data (covering 1966-2004) were utilized in the analysis conducted. Raw data was downloaded from the database as Excel spreadsheets and then processed in Excel to obtain percentage breakdowns by gender, with this derived percentage data used as the basis for the comparative analysis performed in this study.

The NCES data set used includes the following nine academic disciplines under “Science & Engineering”: Engineering, Physical Sciences, Geosciences, Math & Computer Science, Life Sciences, Psychology, Social Sciences, Science & Engineering Technologies, and Interdisciplinary/Other Sciences. For purposes of this analysis, the convention employed by the NSF in its "[Science and Engineering Indicators](#)" report series is used in defining what is considered a “science or engineering discipline.” Under the NSF convention, the following disciplines are not considered a “science or engineering discipline”: 1) Medical Sciences, 2) “Other Life Sciences” (defined as “Life Sciences other than Agricultural, Biological or Medical Sciences”; principally consists of Nursing), 3) Science and Engineering Technologies, and 4) Interdisciplinary/Other Sciences.

3. Analysis of Latest (2004) Data on the Gender Breakdown of Students Earning Bachelor’s Degrees

Table 1 provides a breakdown of earned bachelor’s degrees in the U.S. by gender for 2004 (the latest year for which a complete data set is available), listing both raw numbers and corresponding percentages. The table includes breakdowns considering All Academic Disciplines (i.e., college-wide) and All S&E Disciplines (consisting of the disciplines previously detailed in Section 2), as well as for Engineering (including by sub-discipline) and the five closely-related fields of interest, namely: Chemistry, Physics, Math & Statistics, Computer Science, and Engineering Technology.

Examining Table 1, the following is noted for 2004:

- Overall, women are relatively well-represented in S&E as a whole, earning exactly one-half of all baccalaureates (although the percentage of female baccalaureate-earners in S&E lags that seen college-wide [i.e., considering all academic disciplines] at 50% versus 58%).
- For the six S&E fields considered, the percentage of female baccalaureate-earners in each of these fields ranged widely, with Chemistry and Math & Statistics leading the way (at 51% and 46%, respectively), Computer Science, Physics and Engineering lagging (at 25%, 22% and 20%, respectively), and Engineering Technology recording the lowest level seen at just 14%.
- Taken as a group, the percentage of female baccalaureate-earners in Computer Science, Physics, Engineering, and Engineering Technology was just 21% – well less than one-half the 50% rate seen for S&E overall.
- For the sub-disciplines of Engineering, the percentage of female baccalaureate-earners ranged widely, with Chemical Engineering leading the way (at 35%), Civil Engineering and the “All Other Engineering Fields” category recording intermediate levels (24% and 29%, respectively), and Electrical and Mechanical Engineering lagging behind at just 14% each. (Thus, the percentage of female baccalaureate-earners in Chemical Engineering was two and one-half times that seen in both Electrical and Mechanical Engineering.)

Taken as a whole, the results for 2004 indicate that while S&E is doing reasonably well in achieving gender diversity in its overall baccalaureate graduating class, a closer look reveals areas of substantial weakness within S&E – specifically in Physics, Computer Science, Engineering, and Engineering Technology, where combined, only about one-in-five students earning baccalaureates were women in 2004. (On the other hand, both Chemistry and Math & Statistics are seen to be succeeding in producing a healthy percentage of female baccalaureate-earners, with levels around 50% [one-in-two] recorded in 2004 – equaling the level seen for S&E as a whole.)

With respect to Engineering’s sub-disciplines, the relatively strong interest/achievement noted for women in Chemistry appears to have extended to Engineering as well, where Chemical Engineering was seen to be the Engineering sub-discipline with the largest percentage of female baccalaureate-earners in 2004 (although at a significantly lower level than seen in Chemistry – 35% versus 51%). At the same time, the relative lack of interest/achievement by women in Physics also appears to have extended to Engineering, where Electrical and Mechanical Engineering recorded the lowest percentage of female baccalaureate-earners amongst the major Engineering sub-disciplines in 2004. Also, given that Engineering Technology programs often focus on electro-mechanical studies, it is not surprising to see that the percentage of female baccalaureate-earners in Engineering Technology matches that seen for both Electrical and Mechanical Engineering – 14% in 2004.

4. Time Series Analysis of Data on the Gender Breakdown of Students Earning Bachelor’s Degrees

The time series analysis conducted in this study sought to examine changes in the gender breakdown of students earning bachelor’s degrees over time (specifically covering the period 1966-2004) to identify patterns and trends, as well as to place the previously-discussed results seen for 2004 into historical perspective. For this analysis, two graphs were generated, each plotting the percentage of baccalaureate-earners that are women from 1966 through 2004, with Figure 1 providing values for Engineering and the five closely-related fields of interest, while Figure 2 focuses on Engineering and its sub-disciplines. For reference, corresponding percentages considering “All Academic Disciplines” and “All S&E Disciplines” are plotted in each figure as well.

Examining Figure 1 first, the following is noted:

- Increases seen in the percentage of female baccalaureate-earners considering “All S&E Disciplines” occurred during two distinct periods: 1) the 1970s, when the percentage rose from about 25% to approximately 40% and 2) the 1990s, when the percentage rose from about 40% to nearly 50%.
- In examining the plots for each of the six S&E fields considered, a distinct general pattern is seen whereby: the percentage of female baccalaureate-earners was fairly constant from 1966 through the early-/mid-1970s, then experienced a relatively rapid 10-year rise from the early-/mid-1970s through the early-/mid-1980s (coinciding with the rise and maturation of the women’s liberation movement), with increases continuing at a more modest pace until 2000 and with little change seen since 2000. The one notable exception to this pattern occurs in the case of Computer Science, where a substantial decrease is seen to have occurred from 1984-1993, followed by stabilization at a constant level of around 28%. (The decline noted essentially coincides with a substantial decrease in the number of Computer Science graduates overall, which occurred from 1986-1991. Thus, it appears that women’s interest in Computer Science studies waned faster and declined relatively stronger and over a longer period of time than for men.)
- Chemistry has achieved the most dramatic relative increase overall in the percentage of female baccalaureate-earners, rising from about 20% in 1974 up to 51% in 2004, when it exceeded the level seen for S&E as a whole.
- Up until 1975, there were virtually no (less than 2%) female baccalaureate-earners in Engineering. By 1981, however, Engineering had caught up to Physics in this regard, with the percentage of female baccalaureate-earners in each field seen closely matching each other since that time.
- While Engineering Technology followed the general growth pattern seen for Engineering up through 1981, no further growth in the percentage of female baccalaureate-earners is seen until the late 1990’s. As a result, in 2004, the percentage of female baccalaureate-earners in Engineering Technology stood at about two-thirds that seen for Engineering (14% versus 20%). Additionally, since 1982, Engineering Technology has consistently recorded the lowest percentage of female baccalaureate-earners of any of the six fields examined in this study.

Turning next to Figure 2, the following is noted:

- A distinctive general pattern, similar to that seen in Figure 1 for each of the six S&E fields considered, is also present in Figure 2 for each of Engineering’s sub-disciplines, namely: the percentage of female baccalaureate-earners was fairly constant from 1966 through the early-/mid-1970s, then experienced a relatively rapid 10-year rise from the early-/mid-1970s through early-/mid-1980s (coinciding with the rise and maturation of the women’s liberation movement). At this point, however, two differing trends are seen:
 - For Chemical, Civil, and the “All Other Engineering Fields” category: After a “pause” in the mid-1980s, the percentage continues to rise, but at a more modest rate than earlier seen until 2000, with little change seen since 2000.
 - For Electrical and Mechanical Engineering: The percentage has held fairly steady since the mid-/late-1980s.As a result of this bifurcation, a clear split in Engineering is seen in 2004, with Electrical and Mechanical Engineering – which together account for approximately one-half of all baccalaureates awarded in Engineering – having a collective percentage of female baccalaureate-earners of just 14%, while all remaining Engineering sub-disciplines – accounting for the remaining half of baccalaureates issued in Engineering – having double that percentage at 28%.
- The relative order, in terms of decreasing percentage of female baccalaureate-earners, has remained the same over the entire time period examined, namely: Chemical, “All Other Engineering Fields,” and Civil, with Electrical and Mechanical essentially “tied for last.”

Taken as a whole, the time series analysis conducted reveals that tremendous strides have been made in achieving gender diversity in S&E over the 38-year period examined. Whereas only about one-in-four baccalaureate-earners in S&E were women in 1966, the figure stood at approximately one-in-two in 2004. Furthermore, previously male-dominated fields like Chemistry and Math & Statistics are now seen to have an even mix of male and female baccalaureate-earners, while the previously “males-only” fields of Engineering, Engineering Technology, and Physics now have significant percentages of female baccalaureate-earners.

At the same time, however, the analysis raises significant concerns in terms of revealing that there has been relatively slow to no growth since the mid-1980s in the percentage of female baccalaureate-earners in Engineering, Engineering Technology, Physics, and Computer Science, while since 2000, no significant increase in the percentage has been seen in these fields.

5. Conclusions/Recommendations

While tremendous strides have been made in increasing the gender diversity of undergraduate students graduating from Science & Engineering programs, substantial room for improvement exists within S&E. Through this study, the fields of Physics, Computer Science, Engineering, and Engineering Technology were identified as significant laggards in achieving gender diversity in their graduating baccalaureate classes – collectively, only about one-in-five students earning baccalaureates in these fields were women in 2004, compared to a one-in-two rate seen when considering S&E as a whole. Within Engineering, the sub-disciplines of Electrical and Mechanical Engineering were found to be particularly weak areas where collectively only 14% (about one-in-seven) of baccalaureate-earners were women in 2004 – one-half the 28% level recorded for all other Engineering sub-disciplines combined. Furthermore, the percentages seen for both Electrical and Mechanical Engineering have not substantially changed over the past 20 years (in contrast, the percentage in Chemical Engineering – the sub-discipline with the highest percentage of female baccalaureate-earners historically – increased from 23% to 35% over that same time frame).

Given such statistics, it is intended that this report will serve as a “call to action” to colleges/universities, relevant professional societies, and other appropriate entities to undertake and/or support new or additional efforts/initiatives specifically focused on increasing the enrollment and retention of women nationwide in undergraduate programs in the fields of Physics, Computer Science, Engineering, and Engineering Technology. In this regard, we propose that aggressive national goals be set at achieving 33% (one-in-three) female baccalaureate-earners in Physics, Computer Science, and Engineering (and 25% [one-in-four] in Engineering Technology) by the year 2020. To achieve such ambitious goals in Engineering, particular focus will need to be placed on the lagging sub-disciplines of Electrical and Mechanical Engineering, given that they collectively account for about one-half of all baccalaureate degrees annually granted in Engineering.

TABLES

Table 1: Earned Bachelor's Degrees By Gender In 2004*

Academic Discipline/Field	Both Genders	Female	% Female	Male	% Male
All Academic Disciplines	1,407,009	810,817	58%	596,192	42%
All Science & Eng Disciplines**	454,978	229,412	50%	225,566	50%
Eng & Closely Related Fields***	164,415	41,760	25%	122,655	75%
Chemistry	9,305	4,755	51%	4,550	49%
Physics	4,156	908	22%	3,248	78%
Math & Statistics	13,755	6,318	46%	7,437	54%
Computer Science	57,405	14,406	25%	42,999	75%
Engineering Technology	15,119	2,116	14%	13,003	86%
Engineering	64,675	13,257	20%	51,418	80%
Chemical Engineering	5,185	1,833	35%	3,352	65%
Civil Engineering	9,399	2,279	24%	7,120	76%
Electrical Engineering	21,342	3,032	14%	18,310	86%
Mechanical Engineering	14,368	1,952	14%	12,416	86%
All Other Eng Fields	14,381	4,161	29%	10,220	71%

* - Source: U.S. Dept. of Education’s National Center for Education Statistics' (NCES) survey, “IPEDS Completions Survey – Degrees/Awards Conferred (NSF population of institutions),” with survey data obtained from the National Science Foundation’s WebCASPAR database (online at <http://webcaspar.nsf.gov>).

** - For purposes of this analysis, the convention employed by the National Science Foundation (NSF) in its "[Science and Engineering Indicators](#)" report series is used in defining what is considered a “science or engineering discipline” – see Section 2 of text for details.

*** - Consists of: Chemistry, Physics, Math & Statistics, Computer Science, Engineering Technology, and Engineering.

FIGURES

Figure 1: Percentage Of Female Baccalaureate-Earners In Engineering And Five Closely-Related Fields – 1966-2004*

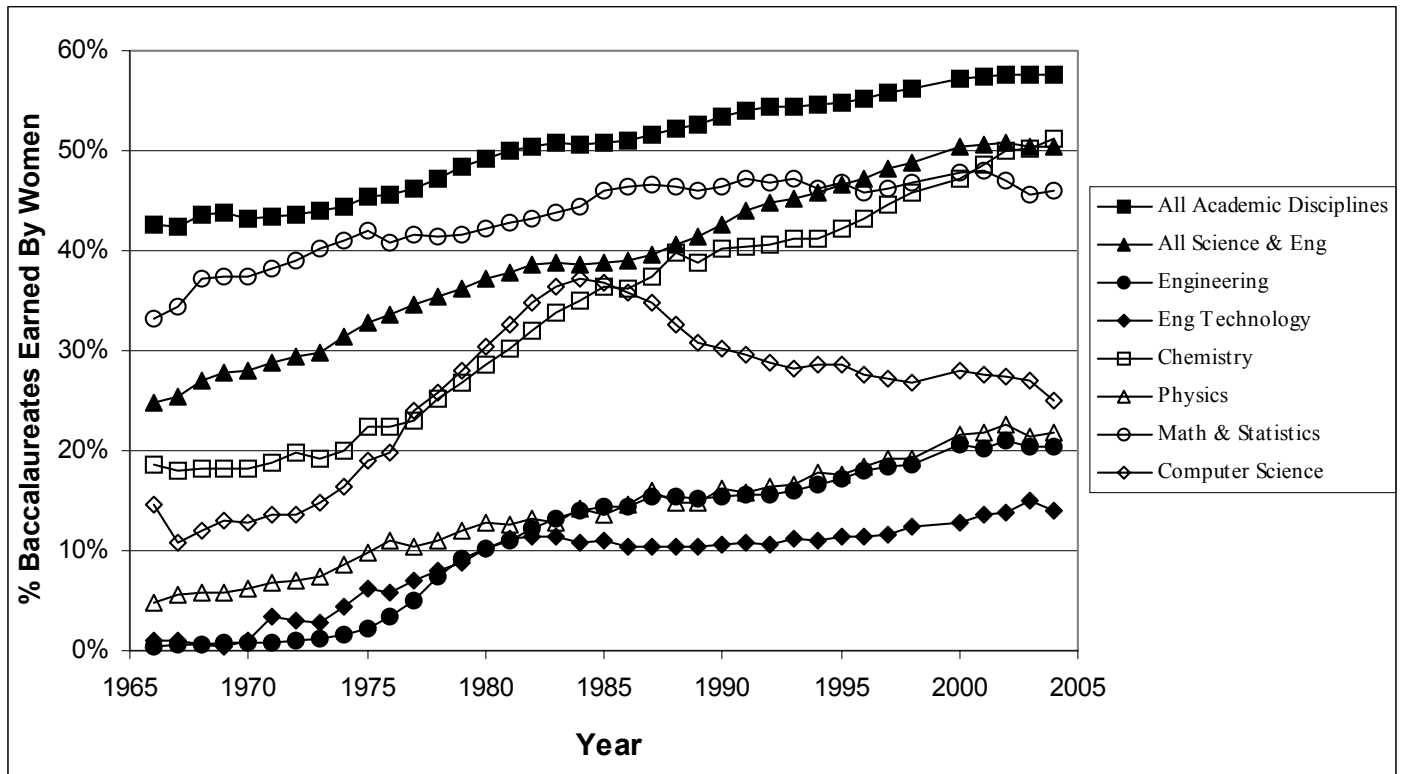


Figure 2: Percentage Of Female Baccalaureate-Earners In Engineering And Its Sub-Disciplines – 1966-2004*

