Exploring the Differences Between Science and Non-Science Majors in an Environment that Controls the Presence of Males

Mark Hamner*, Melinda Holt**

*Mathematics and Computer Science Department
Texas Woman's University

**Mathematics Department
Southeastern Louisiana University

Ebony McGee, Diana Dickey-Davis

Mathematics and Computer Science Department
Texas Woman's University

Funded by Multi-Ethnic Biomedical Research Support Program at Texas Woman's University

Abstract

Women remain sorely under-represented in mathematics, computer science, and the physical sciences. As a result, researchers have attempted to profile female students that choose these majors and to explain why others do not. Several studies suggest that male domination of classrooms and laboratories and the lack of female role models contribute to the disparity. At Texas Woman's University, a majority of faculty members are female, as are over 90% of students. Using a data set that contains information about all current Texas Woman's University undergraduates, the authors have a unique opportunity to explore other variables that often differ across majors while controlling for the factors mentioned above. As part of the current study, the authors evaluated science versus non-science majors. They examined differences in mathematics assessment scores, racial and ethnic make-up, and GPA. *T*-tests and chi-square tests of independence were performed using SAS. These results will be presented and discussed.

Introduction

According to the National Science Foundation and the Department of Education's National Center for Education Statistics, women represent more than half of all college students. Unfortunately they are still under-represented in mathematics and the sciences[1]. The American Association of Engineering Societies reports that this is especially true of engineering[2]. A variety of explanations have been proposed, including the lack of contact with women and female role models [3,4,5,6,7,8,9,10,11,12,13]. In addition, some researchers

identify male domination of classrooms and laboratories as a factor in the under-representation of women in some sciences [7,8,11,14,15,16]. Interestingly, the role of mathematics aptitude in the selection of major is still an open debate [17,18,19,20,21], although high school mathematics preparation has been identified as a factor [22,23].

Texas Woman's University (TWU) offers a unique and encouraging learning environment with a strong female influence. Over 90% of the student population and over 70% of the faculty members are female. As a result, many of the barriers to participation have been removed for young women wishing to pursue the sciences. In response, the authors conducted a study comparing characteristics of science majors to those of non-science majors at TWU. Because the role that mathematics aptitude plays in major selection is still questionable, the authors incorporated the mathematics requirements and mathematics aptitude scores into this exploratory analysis. In addition, we explored issues of race, ethnicity, and GPA.

Method

The Admissions Department at Texas Woman's University provided the data, which consisted of the Fall 2003 enrollment records. These enrollment data included all TWU students from the Houston, Dallas, and Denton campuses. In order to classify between science and non-science students, the number of upper math courses required for each major was evaluated. Those majors with a significant mathematics requirement were deemed as science majors for the purposes of this study. All biology, chemistry, computer science and mathematics majors were classified as science majors, while the remaining majors were considered non-science. The variables evaluated from the data set included: gender, ethnicity, classification, major, Math SAT scores, cumulative GPA, total hours accumulated, and admission status.

The authors tested three hypotheses pertaining to the science and non-science majors. First, we used a two-sample t-test to compare the average Math SAT scores of science and non-science majors at TWU. In addition, we asked whether or not the chosen major of students was independent of ethnicity by doing a chi-squared test of hypothesis. Finally, we explored the relative success of science majors versus non-science majors by using a two-sample t-test to assess if the average cumulative GPA for Science majors differs from the average cumulative GPA for non-science majors

Results

As indicated in Table 1, the total number of undergraduate TWU students in Fall 2003 was 7,273. Approximately 75% of those students did not have a recorded Math SAT score. In addition, less than 7% of the total undergraduate students are science majors. The science majors have 218 total Math SAT scores and the non-science majors have 1,522. However, the 218 SAT scores from the science majors represented 44.4% of their total, whereas the 1522 SAT scores from the non-science majors represent only 22.4% of their total. This disparity is worth further investigation. We do note once more that other

valid entrance criteria such as the ACT and class rank were not considered in our analysis but might be of interest in future research.

Table 1:

Cumulative GPA and SAT Scores By Major					
Major Group	**Total Students**	**# Of Students With SAT Math Scores**	**Average SAT Math Score**	**% With SAT Math Scores**	**Average GPA**
Science	490	218	495	44.4%	3.0563907
Non-Science	6,783	1,522	468	22.4%	3.2563277
Total	**7,273**	**1,740**	**472**	**23.9%**	**3.2430075**

In this study we wanted to compare Math SAT scores of students who chose to be science majors verses the students who chose to be non-science majors. From Chart 1 we see that the shape of the histogram of Math SAT scores for both science and non-science majors are reasonably symmetrical in shape with no apparent outliers. However, the histogram for the science majors is shifted further right than that of the non-science major. This shift is evidenced by the larger average SAT Math score of 495 for the science major versus the average SAT Math score of 468.32 for the non-science major (see Table 2). Analogously the larger standard deviation for the science majors is demonstrated by the wider spread of the histogram.

Chart 1:

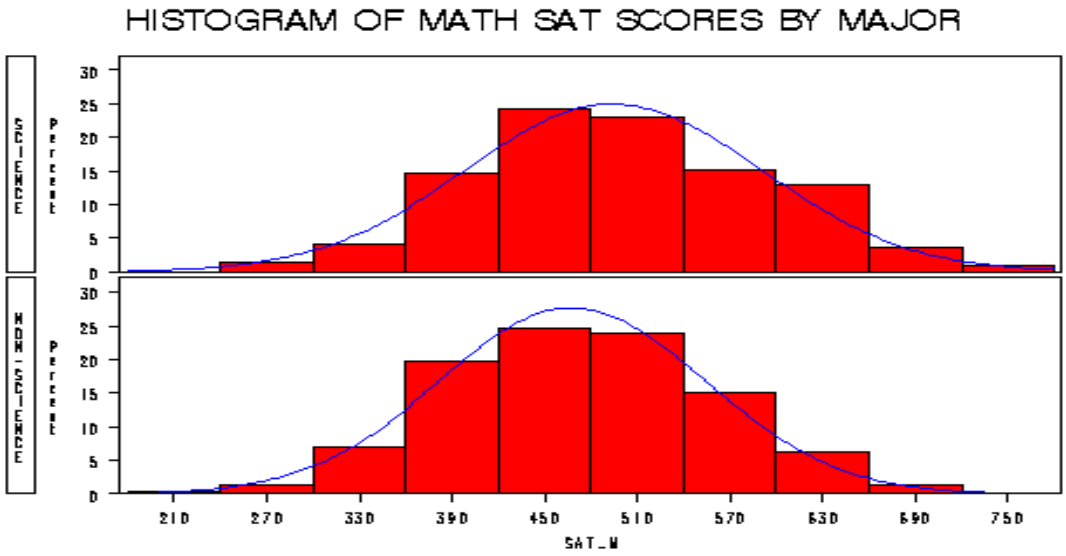

Table 2:

SAT Math Scores by Major							
Variable	**Major**	**N**	**Mean**	**Std Dev**	**Std Err**	**Minimum**	**Maximum**
Sat_M	**Non-Science**	1518	468.32	86.426	2.2182	200	740
Sat_M	**Science**	218	495	95.951	6.4987	240	760
Sat_M	**Diff (1-2)**		-26.68	87.675	6.3502		

A two-sample t-test found a significant difference ($p<0.0001$) between the average Math SAT score of the science majors versus the average Math SAT score of the non-science major. It appears that on average the science majors have higher Math SAT scores than non-science majors.

Next we consider the ethnic composition by major. A chi-square procedure showed that choice of major was not independent of ethnicity ($p<0.0001$). Surprisingly, however, Table 3 shows that minorities are represented in the sciences at a higher rate than expected. At TWU, minorities are actually better represented in the sciences than in the non-sciences. It is important to point out that a variety of possible explanations exist, including small class sizes, an almost entirely female student body, and the abundance of female role models. One additional explanation is the presence of several support programs such as the TWU Multi-Ethnic Biomedical Research Program, the Women In eNgineering (WIN), and the Computer Science, Engineering, and Mathematics Scholars (CSEMS).

According to the National Science Foundation[1], the percentage of earned bachelor's degrees for the year 2000 in science and engineering for underrepresented minorities is 15.6%. This 15.6% total in bachelor 's degrees earned in science and engineering breaks down into 8% Blacks / No- Hispanics, 6.9% Hispanics and 0.7% American Indian or Alaskan Natives. At TWU the total percentage of underrepresented minorities in the sciences is 38.8% of the 484 total science majors with known ethnicity. In fact, 24.79% of the science majors at TWU are black/Non-Hispanic, 13.22% are Hispanic, and .83 % are American Indian/Alaskan. In each case the percentage of underrepresented minority science majors at TWU exceeds the national percentage of earned bachelor's degrees for underrepresented minorities in science and engineering in 2000.

Table 3:

Major By Ethnicity							
Major	**Ethnic**						
Frequency Row Pct Col Pct	**White, Non-Hispanic**	**Black, Non-Hispanic**	**Hispanic**	**Asian Amer/ Pac. Isl.**	**Amer. Indian/ Alaskan**	**International**	**Total**
Science	237 48.97 5.32	120 24.79 8.60	64 13.22 8.02	37 7.64 11.31	4 0.83 6.90	22 4.55 14.67	484 100.00 6.74
Non-Science	4218 62.96 94.68	1275 19.03 91.40	734 10.96 91.98	290 4.33 88.69	54 0.81 93.10	128 1.91 85.33	6699 100.00 93.26
Total	4455 62.02	1395 19.42	798 11.11	327 4.55	58 0.81	150 2.09	7183 100.00
Frequency Missing = 90							

Once the choice has been made to become a science major the student is then faced with the task of completing the requirements so that they can graduate. Overall GPA is an indicator of potential success, which we now compare across major. Note that if a student in the Fall 2003 data set had not accumulated any hours of credit as of Fall 2003 at TWU then their cumulative GPA is missing. Thus, we have 5,576 overall GPA

observations for the non-science majors and 398 overall GPA observations for the science majors (see Table 4). These observations are plotted in Chart 2 where we see that the shape of the histogram of overall GPA for both science and non-science majors are slightly left skewed. However, the average GPA of 3.2563 for the non-science major is larger than the average GPA of 3.0564 for the science major.

Chart 2:

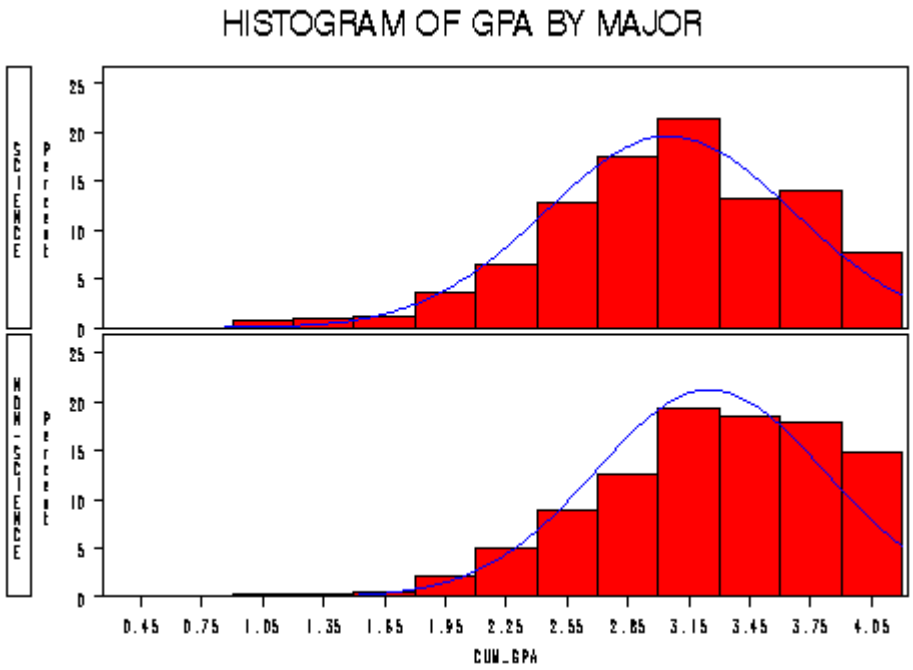

Table 4:

Cumulative GPA by Major							
Variable	**MAJOR**	**N**	**Mean**	**Std Dev**	**Std Err**	**Min.**	**Max.**
CUM_GPA	**NON-SCIENCE**	5576	3.2563	0.564	0.0076	0.4375	4
CUM_GPA	**SCIENCE**	398	3.0564	0.6096	0.0306	1	4
CUM_GPA	**Diff (1-2)**		0.1999	0.5671	0.0294		

A two-sample t-test found a significant difference ($p<0.0001$) between the average GPA of the science majors versus the average GPA of the non-science major. It appears that on average the science majors have lower overall GPA than non-science majors, a phenomenon that is somewhat universal to post-secondary education. Table 5 shows that average GPA is lower in the sciences than in the general population for each ethnic group except international students and those with unknown ethnicity. Table 5 also demonstrates that average Math SAT scores are higher among science majors than the general population for all ethnic groups. Worth noting, however, is the apparent positive correlation between Math SAT score and science GPA within the sciences and the

general TWU population. Although not a part of the current study and not surprising, this relationship is worth future study.

Table 5:

SAT Score and GPA By Ethnicity				
Ethnic Group	**Science Average Math SAT Score**	**Science Average GPA**	**Overall Average Math SAT Score**	**Overall Average GPA**
White, Non-Hispanic	537	3.2329187	505	3.3387446
Black, Non-Hispanic	422	2.649443	410	2.946859
Hispanic	484	3.050602	455	3.2072697
Asian Amer/Pac. Isl.	519	3.0828321	502	3.285374
Amer. Indian/Alaskan	450	2.7961333	425	3.2170442
International	595	3.403425	544	3.2935244
Unknown	430	3.063	464	2.9825686
Total	**495**	**3.0563907**	**472**	**3.2430075**

Conclusions

We found that, at TWU where classes include almost entirely women, minorities are well represented in the sciences. A contributing factor, at least in part, is TWU's unique and encouraging learning environment that allows young women exposure to a large selection of female role models. In addition, the typical small class size provides an encouraging environment in which struggling students may feel more comfortable asking for help. Indeed, despite the struggle science majors might encounter with their curriculum and maintaining their overall GPA, at TWU underrepresented minority participation in the sciences is nearly 40% of all science majors.

References

[1] National Science Foundation, Computer-Aided Science Policy Analysis and Research (WebCASPAR Database), www.nsf.gov/sbe/srs/srsdata.htm.

[2] American Association of Engineering Societies, Engineering and Technology Enrollments, 2001, Engineering Workforce Commission 2001 – 2002.

[3] Frenkel, K.A., "Women and Computing," *Communications of the AC,* 1990, 34-46.

[4] Haemmerlie, F.M. and R.L. Montgomery, in S. Blaisdell, ed., *Factors in the Underrepresentation of Women in Science and Engineering: A Review of the Literature*, Women in Engineering Program Advocates Network (WEPAN) Report, 1991.

[5] Evans, M.A., *Undergraduate Survey for the Program for Women in Science and Engineering*, 1993, Unpublished manuscript.

[6] Cosgrove, C.R., Blaisdell, S. and M.R. Anderson., in S. Blaisdell, ed., *Factors in the Underrepresentation of Women in Science and Engineering: A Review of the Literature*, Women in Engineering Program Advocates Network (WEPAN) Report, 1994.

[7] Harrington, S.M., *Barriers to Women in Undergraduate Computer Science: The effects of the Computer Environment on the Success and Continuance of Female Students*, 1990, Unpublished dissertation.

[8] Seymour, E., "The Loss of Women from Science, Mathematics, and Engineering Undergraduate Majors: An Explanatory Account.," *Science Education* 79(4), 1995, 437-473.

[9] Cunningham, C., M. Pavone and C. Muller, *Factors Influencing Women's Pursuit of a College Science Major or Science Career: An evaluation of the Women in Science Project (WISP)*, WEPAN Conference Proceedings, 1996, 289-294.

[10] Santovec, M.L., "Campus Climate Affects Female Engineering Undergrads," *Women in Higher Education* 8 (7), 1999, 5.

[11] Carver, D.L., *Research Foundations for Improving the Representation of Women in the Information Technology Workforce: Virtual Workshop Report*, National Science Foundation, 2000, www.cise.nsf.gov/itwomen.html.

[12] Garcia, O.N. and R. Giles, *Research Foundations on Successful Participation of Underrepresented Minorities in Information Technology: Final Report from a Cyber Conference*, National Science Foundation www.cise.nsf.gov/itminorities.html, 2000.

[13] Camp, T., "Women in Computer Sciences: Reversing the Trend in Science and Engineering," *Syllabus* 15, 2001, 24-28.

[14] Morgan, C.S., "College Students' Perception of Barriers to Women," *Youth and Society* 24 (2), 1992, 228-236.

[15] Bunderson, E. D.; Christensen, M. E., "An Analysis of Retention Problems for Female Students in University Computer Science Programs," *Journal of Research on Computing in Education* 28(1), 1995, 1-19.

[16] American Association of University Women Education Foundation Commission on Technology, Gender, and Teacher Education (AAUW), *Tech-Savvy: Education Girls in the New Computer Age*, American Association of University Women Education Foundation, 2000.

[17] Ware, N. N. Steckler, and J. Leserman, Undergraduate Women: Who Chooses a Science Major? *Journal of Higher Education* 56, 1985, 73-84.

[18] Whipkey, K.L. and J.T. Stephens, Identifying Predictors of Programming Skill, *ACM SIGCSE* 16 (4), 1984, 36-42.

[19] Butcher, D.F. and W.A. Muth, Predicting Performance in an Introductory Computer Science Course. *Communications of the Association for Computing Machinery* 28 (3), 1985, 263-268.

[20] Seymour, E., The Loss of Women from Science, Mathematics, and Engineering Undergraduate Majors: An Explanatory Account. *Science Education* 79(4), 1995, 437-473.

[21] Brainard, S.G. and L. Carlin, A Six-Year Longitudinal Study of Undergraduate Women, *Journal of Engineering Education*, 1998, 369-375.

MARK S. HAMNER
Dr. Hamner currently serves as an Assistant Professor at Texas Woman's University in the Department of Mathematics and Computer Science. His research interest includes Bayesian finite population prediction in survey sampling and intelligent tutoring using the Bayesian Algorithm.

MELINDA MILLER HOLT
Dr. Holt currently serves as an Associate Professor in the Department of Mathematics at Southeastern Louisiana University. Her research interest includes Bayesian biostatistics, statistics education, and gender issues in higher education.

EBONY MCGEE
Ms. McGee recently completed her B.S. in computer science from Texas Woman's University, where she participated in the Multi-Ethnic Biomedical Research Program and WIN. She is now beginning graduate study in electrical engineering at Texas Tech University.

DIANA DICKEY-DAVIS
Ms. Davis recently completed her B.S. in computer science from Texas Woman's University, where she participated in the Multi-Ethnic Biomedical Research Program and WIN. She is now beginning graduate study in electrical engineering at Texas Tech University.