Gender Grade Analysis Over Four Semesters in an Environmental Engineering Course

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Abstract

Retention of students in engineering fields is important to meet the estimated future workforce demand for engineers in the United States. Women are an underrepresented group in engineering. This study was undertaken to compare grades of women and men in a required, upper-level environmental engineering course to assess differences in student performance. Three indicators were chosen to assess course performance: final course grade, final exam grade, and homework completion rates. Comparisons were made between the chosen indicators for averages, standard deviations, and analysis of variance tests. The conclusion was that the performance of men and women were not statistically different for any of the indicators. These findings are consistent with other studies. These findings support the conclusions of other researchers that there are other or additional factors besides grades that cause women to leave engineering majors.

Introduction

Efforts to attract and retain students in engineering fields have increased over the past several years (Tseng et al., 2011; Honken and Ralston, 2013). Women are an underrepresented group in the engineering community. It was estimated that in 2009 only 17.8 % of bachelor degrees were obtained by women in the United States (Backer et al., 2012). In 2010, that estimate rose to 18.4% of degrees being awarded to women, but this is still low (Lee et al., 2015). Thus, research is being conducted in the United States on methods to retain women in engineering programs which should help to meet the industry demand for engineers (Concannon and Barrow, 2009; Marra et al., 2009; Sonnert and Fox, 2010; Haemmerlie and Montgomery, 2012; Poor and Brown, 2013; Riderer and Hawley, 2013).

Previous studies noted that many women leave engineering programs due to a lack of self-confidence as opposed to poor performance in course work (Brainard and Carlin, 1998). Early studies found that female students had lower GPAs than their male counterparts; however more recent studies are finding that this is no longer true. Reasons for this departure from the historic trend include better academic preparation in pre-college schooling, confidence in academic abilities, family support, and a high expectations of success in engineering (Blaisdell, 2000; Vogt et al., 2007).

Blaisdell (2000) studied over 200 high school students who were interested in majoring in engineering. The study concluded that females who intended to major in engineering were more likely to enroll in a college engineering program than high school males who showed interest in engineering. In addition the study found that these high school females had statistically higher GPAs than the male high school students who intended to major in engineering.

Amelink and Meszaros (2011) studied engineering student populations at multiple universities to determine factors that influence women to stay or leave engineering. The study found that grades were a reason for discouragement in engineering for both male and female students. However a gender grade comparison was not conducted. Haemmerlie and Montgomery (2012) studied an incoming freshman class in Fall 2007. The study compared student GPA at the end of the second semester and retention for the following year in an engineering major. The study found no correlation between returning female students and their respective GPAs. A difference between these two studies is that one studied perception of grades and one actual grades.

There is a deficit of studies using data analysis of student performance in the classroom which provide important insights into student performance (Prieto et al., 2009; Amelink and Meszaros, 2011). Such practitioner case studies can be used to improve classroom educational practices (Corcoran et al., 2004). In addition grades and GPAs have been shown to be an indicator of retention of women in engineering and science curriculum (Sonnert and Fox, 2012). Thus, this study was undertaken to compare student performance. This study evaluates the grades in a required senior level environmental engineering class to determine if there were statistically significant differences in female and male student performance.

Methods

An instructor taught a 400-level Environmental Engineering (EVE) course at a state university in Southern California for four consecutive semesters. The courses were taught from Fall 2011 to Spring 2013. Data on student performance were separated by gender for this study. Three indicators were chosen to represent student performance in the course: final course grade, final exam grade and homework completion. Grades and GPAs are regarded as an indicator of performance in undergraduate studies (Sonnert and Fox, 2012). Homework completion rates are used as indication of effort in the class.

Statistical analyses were performed on the data using Microsoft Excel®. Analysis of Variance (ANOVA) tests were conducted at the 95% confidence level to assess differences between the data sets. Normal distribution was assumed. Three indicators were chosen to evaluate the differences: final course grade, final exam grade, and homework completion. Course grades were on a 4-point scale (A = 4, B = 3, C = 2, D = 1, and F = 0). Plus and minus grades were used in the course. The final exams are not returned to the students so the same exam was used each semester. The exams contained 100 points of comprehension and quantitative questions. There were also 10 points of extra credit; however if a student attempted the extra credit and did not make correct answers no points were taken off of the exam grade. It is important to note that the analysis on homework was for turning in the assignment only and not based on the grades received on the homework assignments.

The number of students in each class is shown in Table 1. These numbers translate to the percent of female students in each class as 15.9%, 17.4%, 17.5%, and 20.8%, respectively. These values are on par with national estimates of female representation in engineering (Backer et al., 2012; Lee et al., 2015). The Association of Environmental Engineering and Science Professors (AEESP) conducted a study on 2003-2004 data and found there were higher

percentages of women in Environmental Engineering than in engineering overall. Women received 42% of Bachelor of Science (BS) environmental engineering degrees compared to 20% of BS degrees from all engineering. In the workforce, women accounted for approximately 22% of environmental engineers but only 11% of engineering workforce overall (Bhandari et al., 2006). It is important to note that the study did not mention whether the BS degrees were part of a Civil & Environmental Engineering department or a separate Environmental Engineering department and whether or not the later were ABET accredited.

Table 1: Gender averages of indicators

	Number of students		Final Exam Grades (110)		Course Grades (4.0 scale)		Number of homework assignments completed (7)	
Term	Male	Female	Male	Female	Male	Female	Male	Female
Fall 2011	53	10	61.7	61.6	2.6	2.9	5.1*	5.5*
Spring 2012	38	8	59.3	72.9	2.8	3.4	6.2	6.6
Fall 2012	52	11	80.8	74.2	2.7	2.4	6.4	6.8
Spring 2013	38	10	76	78	2.3	2.5	6.3	6.3
All Terms	181	39	69.7	71.7	2.6	2.8	5.9	6.6

*A total of 6 homework assignments were assigned in Fall 2011

Results

The female students outperformed the male students in both the overall course grade and the final exam grade in two of the four semesters and earned essentially the same average score as their male counterparts in one semester (Table 1). The only semester where the male students averaged higher course and final exam grades than the female students was in Fall 2012. In addition the females had higher homework completion rates in the three of the four semesters and in the fourth semester the completion rates were equal.

The minimum scores received in each category are presented in Table 2. A female student had the lowest final exam grade in only one of the four semesters. And a female student did not receive the lowest grade in any of the four semesters studied. In addition, the females completed more homework assignments than their male counterparts in all four semesters. The maximum final exam grades did not follow any trends. In Fall 2011 the maximum male grade (98) was higher than that for a female (88); which also occurred in Fall 2012 (male scored 108 and female 93). In Spring 2012 the maximum female final grade (95) was higher than the highest male grade (93); which also occurred in Spring 2013 (male scored 104 and female scored 109). The maximum course grade received by a male was 4.0 (A+) in each semester. The maximum grade for a female in three of the four semesters was 4.0; in Fall 2012 the maximum grade was 3.3 (A-). The maximum number of homework assignments completed by both a male and female student was 6 or 7 depending on the number of homework assignments assigned that semester.

Table 2: Minimum scores obtained on indicators

	Final Exam Grades (110)		Course Grades (4.0 scale)		Number of homework assignments completed (7)	
Term	Male	Female	Male	Female	Male	Female
Fall 2011	0	29	0	1	0	4
Spring 2012	0	55	0	2.3	0	5
Fall 2012	45	39	0	1	0	5
Spring 2013	32	45	0	0.7	2	5
All Terms	0	29	0	0.7	0	4

The standard deviations for each category are shown in Table 3. In general the standard deviations are similar between the male students and the female students. The female students had lower standard deviations than the males all four semesters for the course grades and homework completion. The largest differences were in Spring 2012 where the female students had lower standard deviations for all three categories than the male students. This indicates that the females are performing more similar to each other than the male students. Standard deviation is an indication of the spread of the data (Berthouex and Linfield, 2002).

Table 3: Standard deviations of indicators

	Final Exam Grades (110)		Course Grades (4.0 scale)		Number of homework assignments completed (7)	
Term	Male	Female	Male	Female	Male	Female
Fall 2011	22.4	21.9	1.21	1.20	1.70	0.71
Spring 2012	21.9	12.8	1.22	0.61	1.50	0.74
Fall 2012	14.0	16.3	0.99	0.66	1.33	0.60
Spring 2013	18.1	18.2	1.17	1.13	1.24	0.82
All Terms	21.3	18.2	1.15	0.98	1.56	0.86

Discussion

The discussion is broken up into sections. The first section will discuss statistical analyses on the data and the second section is a comparison to other studies on the topic.

Statistical analyses

There were no statistically significant differences between male and female students in any of the semesters for any of the three indicators (Table 4). This shows that male students are not outperforming female students or vice versa.

Table 4: ANOVA results of gender comparisons for indicators

Term	Course Grade	Final Exam Grade	Homework Completion
Fall 2011	No (P = 0.51)	No (P = 0.99)	No (P = 0.42)
Spring 2012	No (P = 0.19)	No (P = 0.10)	No (P = 0.45)
Fall 2012	No (P = 0.26)	No (P = 0.17)	No (P = 0.27)
Spring 2013	No (P = 0.69)	No (P = 0.76)	No (P = 0.92)
All Terms	No (P = 0.54)	No (P = 0.59)	No (P = 0.16)

Comparison to other studies

Stump et al. (2011) studied 14 Mechanical and Aerospace Engineering courses resulting in 513 responses (429 male and 84 female). The students were graded on a 4-point scale were an A+ was 4.33 points (in this study both A and A+ were 4 points) and found that women had a slightly higher average GPA than their male counterparts. The mean cumulative GPA was 3.13 for males and 3.36 for females. The range was 0.00 to 4.18 for the males and 2.08 to 4.33 for females. These results are similar to the grades received in the courses that were surveyed where the mean course grade for females was 2.99 and 2.78 for males. Both genders' course grades ranged from 0 to 4.33. The authors concluded that the grades of females and males are not statistically different. That is consistent with the findings in this study.

Vogt et al. (2007) studied 713 students (409 males and 304 females) from four research universities on the West Coast. The study found no statistically significant difference between the GPA of male and female students as was found in this study.

Sonnert and Fox (2012) conducted a study using 16 years of data from multiple universities to determine grade disparities between genders. GPAs ranged from 4 points for an A to 0 points for an F. The study found the average female GPA was 0.1 point higher than male GPAs. This study included both sciences and engineering and engineering as a separate analysis and found the same result: no significant difference.

Takahira et al. (1998) studied over 5, 000 students across 17 universities in Statics courses. The study found that the there was no statistically significant difference between the final grades between male and female students. The average male GPA was 2.43 and for females was 2.46. These results are similar to this study which found only a negligible difference between the data sets.

Conclusions

The loss of women from EVE degree programs could affect the gender gap in engineering, especially as previous research has shown a relatively high percentage of women are interested in EVE. This research shows that women are academically competitive with their male counterparts. This conclusion is consistent with current studies in the field.

References

Amelink, Catherine T; Meszaros, Peggy S. 2011. A comparison of educational factors promoting or discouraging the intent to remain in engineering by gender. *European Journal of Engineering Education*, 36 (1), 47-62.

Backer, Patricia R.; Halualani, Rona Tamiko. 2012. Impact of Self-Efficacy on Interest and Choice in Engineering Study and Careers for Undergraduate Women Engineering Students. *Proceedings of the American Society of Engineering Education Annual Conference 2012*.

Berthouex, Paul Mac; Linfield C. Brown, *Statistics for Environmental Engineers, 2nd edition*. CRC Press, Boca Raton, FL, 2002, pp. 10-11.

Bhandari, A., Jones, S. A., Clapp, L. W., Fennell, D. E., LaPara, T. M. 2006. Diversity in environmental engineering—successes and challenges. *Journal of Environmental Engineering*, 701-702.

Blaisdell, Stephanie. 2000. Students' decisions to enter engineering: how men and women differ. *Proceedings of the WEPan National Conference*, June 25-27, 2000,Washington, DC, p. 243-251.

Brainard, Suzanne G.; Carlin, Linda. 1998. A Six-Year Longitudinal Study of Undergraduate Women in Engineering and Science. *Journal of Engineering Education*, October 1998, 369-375.

Concannon, James P.; Barrow, Lloyd H. 2009. A cross-sectional study of engineering students' self-efficacy by gender, ethnicity, year and transfer status. *Journal of Science Education & Technology*, 2009, 18, 163-172.

Corcoran, P. B., Walker, K. E., & Wals, A. E.J. 2004. Case studies, make your case studies, and case stories: a critique of case study methodology in sustainability in higher education. *Environmental Education Research, 10*(1), 7-21.

Haemmerlie, Frances Montgomery; Montgomery, Robert L. 2012. Gender differences in the academic performance and retention of undergraduate engineering majors. *College Student Journal*, 46 (1), 40-45.

Honken, N., & Ralston, P. A. S. 2013. Freshman Engineering Retention: A Holistic Look. *Journal of STEM Education*, 14(2), 29-37.

Lee, Hang-Shim; Flores, Lisa Y.; Navarro, Rachel; Kanagui-Munoz, Marlen. 2015. A Longitudinal Test of Social Cognitive Career Theory's Academic Persistence Model among Latino/a and White Men and Women Engineering Students. *Journal of Vocational Behavior*, doi: 10.1016/j.jvb.2015.02.003

Marra, Rose M.; Rodgers, Kelly A.; Shen, Demei; Bogue, Barbara. 2009. Women Engineering Students and Self-Efficacy: A Mulit-Year, Multi-Institution Study of Women Engineering Student Self-Efficacy. *Journal of Engineering Education*, January 2009, 27-38.

Poor, Cara J.; Brown, Shane. 2013. Increasing retention of women in engineering at WSU: A model for a women's mentoring program. *College Student Journal*, 47 (3), 421-428.

Prieto, E., Holbrook, A., Bourke, S., O'Conner, J. Page, A., & Husher, K. 2009. Influences of engineering enrolments. A synthesis of the findings of recent reports. *European Journal of Engineering Education*, *34*(2), 183-203.

Riderer, Lucia; Hawley, Harmonie A. 2013. Encouraging Women to Transfer into Engineering Programs from 2-Year to 4-Year Colleges. *Proceedings of the 2013 American Society for Engineering Education Pacific Southwest Conference*, April 18 -20, 2013, Riverside, CA.

Sonnert, Gerhard; Fox, Mary Frank. 2012. Women, Men, and Academic Performance in Science and Engineering: The gender differences in undergraduate grade point averages. *The Journal of Higher Education*, 83 (1), 73-101.

Stump, Glenda S.; Hilpert, Jonathan C.; Husman, Jenefer; Chung, Wen-Ting; Kim, Wonsik. 2011. *Journal of Engineering Education*, 100 (3), 475-497.

Tseng, T., Chen, H. L., & Sheppard, S. 2011. Early Academic Experiences of Non-Persisting Engineering Undergraduates. *Proceedings of the 2011 American Society of Engineering Education Annual Conference & Exposition*.

Takahira, Sayuri; Goodings, Deborah J.; Byrnes, James P. 1998. Retention and performance of male and female engineering students: An examination of academic and environmental variables. *Journal of Engineering Education*, July, 297-304.

Vogt, Christina M.; Hocevar, Dennis; Hagedorn, Linda Serra. 2007. A social cognitive construct validation: determining women's and men's success in engineering programs. *The Journal of Higher Education*, 78 (3), 337-364.