Work In Progress – Do Women Score Lower Than Men on Computer Engineering Exams?

I-Ju Liao and Michael C. Loui
University of Illinois at Urbana-Champaign
{ijuliao@uiuc.edu, loui@uiuc.edu}

***Abstract* – Women have long been underrepresented in undergraduate engineering programs. Women may drop out of engineering programs when they become discouraged by low exam scores. In this project, we examine whether women earn lower exam scores than men and whether Dweck's model of self-theories explains the difference. Dweck proposed two categories for individuals' beliefs about intelligence: incremental theories and entity theories. Dweck found that women are more likely to be entity theorists than men. In our study, we found that the difference between exam averages between women and men, and between entity and incremental theorists were not statistically significant.**

Index Terms – Women in engineering, exam performance, self-theories.

INTRODUCTION

In the United States, women have always been underrepresented in engineering and computer science. According to the National Science Foundation [1], 20.11% of all bachelor's degrees in engineering are awarded to women in 2001.

Felder et al. [2] conducted a longitudinal study on the performance and attitudes of women and men in five chemical engineering courses. Felder et al. found that in these courses, the grades of men were consistently equal to or higher than the grades of women.

In this study, we compare exam scores of different populations to determine whether lower exam scores could explain the underrepresentation of women in engineering.

DWECK'S THEORY OF INTELLIGENCE

Educational psychologist Carol Dweck [3] classifies people into two groups: incremental theorists and entity theorists. Incremental theorists believe that intelligence can improve with learning, but entity theorists believe intelligence cannot be changed. By conducting many research studies on how fifth-graders solve mathematical problems, Dweck found that incremental theorists and entity theorists differed when they face difficult problems. Entity theorists react by blaming themselves for not being smart enough, and incremental theorists react by saying the problem can be solved with more knowledge or effort. Incremental theorists believe they can solve any difficult problem with more learning, but entity theorists believe they can never solve some difficult problems because their intelligence level cannot be improved. Dweck discovered that entity theorists perform worse on difficult problems than incremental theorists, and that young women tend to be entity theorists. Consequently young women are more likely to give up on problems they think are too difficult.

Heyman et al. [4] found that among engineering students, 72% of women held entity beliefs about engineering aptitude, but only 46% of men did so. Of women who reported that they dropped a course when faced with difficulty, 100% held entity beliefs. Of women who persisted through a difficult course, only 61% held entity beliefs.

METHODS

To determine whether students' exam scores are correlated with gender, we collected examination scores in the Fall 2004 offerings of two large core computer engineering courses at the University of Illinois at Urbana-Champaign: ECE 110 and ECE 290. These courses contain primarily freshmen and sophomores, respectively.

At the beginning of the semester, we administered a survey to collect data on the students' gender, their ACT/SAT Math scores, their experience with computers prior to college, and their study habits. All SAT Math scores were converted to ACT Math scores with a standard table. Each survey included the "Theories of Intelligence Scale" questionnaire developed by Dweck [3]. This questionnaire classifies students as incremental theorists, entity theorists, or neither.

RESULTS

To test whether women scored lower than men on exams, we applied the two-tailed t test to data with a normal distribution, and we applied the Mann-Whitney U test to data without a normal distribution. Tables I and II provide exam averages for men and women as well as t test and Mann-Whitney U test results for ECE 110 and ECE 290. All exam scores were scaled linearly to the 0–100 range.

TABLE I
COMPARISON OF EXAM AVERAGES BETWEEN WOMEN AND MEN FOR ECE 110

		Women	Men	Significance
Exam 1	n	29	223	$p < 0.50$
	Average	77.3	78.7	
Exam 2	n	29	222	$p < 0.79$
	Average	82.5	83.4	
Exam 3	n	28	220	$p < 0.27$
	Average	68.7	71.5	
Final Exam	N	28	218	$p < 0.90$
	Average	80.1	80.2	

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TABLE II
COMPARISON OF EXAM AVERAGES BETWEEN WOMEN AND MEN FOR ECE 290

		Women	Men	Significance
Exam 1	*n*	15	142	$p < 0.80$
	Average	67.8	67.0	
Exam 2	*n*	15	139	$p < 0.41$
	Average	88.5	87.1	
Final Exam	*n*	15	139	$p < 0.77$
	Average	58.2	59.2	

In ECE 110, although the average score for women was slightly lower than that of men on each exam, this difference was not statistically significant at the 0.05 level. In ECE 290, the average scores for women were higher on the first two exams but lower for the final. Again, the differences of the averages on all exams were not statistically significant at the 0.05 level. For both courses, we can conclude that women did not score significantly lower on exams than men.

To test whether entity theorists perform worse on exams in our population, we applied the two-tailed *t* test to data with a normal distribution, and we applied the Mann-Whitney *U* test to data without a normal distribution. Tables III and IV provide exam averages for entity and incremental theorists as well as *t* test and Mann-Whitney *U* test results for ECE 110 and ECE 290.

TABLE III
COMPARISON OF EXAM AVERAGES BETWEEN ENTITY AND INCREMENTAL THEORISTS FOR ECE 110

		Entity	Incremental	Significance
Exam 1	*n*	90	117	$p < 0.28$
	Average	79.4	77.1	
Exam 2	*n*	90	117	$p < 0.32$
	Average	84.8	82.7	
Exam 3	*n*	88	116	$p < 0.11$
	Average	71.9	69.9	
Final Exam	*n*	86	116	$p < 0.39$
	Average	80.9	79.5	

TABLE IV
COMPARISON OF EXAM AVERAGES BETWEEN ENTITY AND INCREMENTAL THEORISTS FOR ECE 290

		Entity	Incremental	Significance
Exam 1	*n*	60	75	$p < 0.05$
	Average	71.1	64.9	
Exam 2	*n*	59	73	$p < 0.057$
	Average	88.9	86.2	
Final Exam	*n*	59	73	$p < 0.05$
	Average	62.7	57.1	

Although the differences between exam averages were statistically significant for exam 1 and the final exam in ECE 290, the entity theorists performed better. For all other exams, there were no significant difference between the averages of the entity theorists and the incremental theorists. We can conclude that entity theorists do not score lower on exams.

We used the following regression model to determine whether women performed worse than men after controlling for ACT Math scores:

$$Exam = \beta_0 + \beta_1 Gender + \beta_2 ACTMath + \beta_3 Gender \times ACTMath$$

Tables V and VI present the regression models. The *p* values for the estimates of the β_2 parameter indicate that exam scores are significantly correlated with ACT Math scores. Further, after controlling for ACT Math scores, the *p* values for the estimates of the β_1 and β_3 parameters indicate that women did not perform worse than men.

TABLE V
REGRESSION MODEL RESULTS FOR ECE 110

		Exam 1	Exam 2	Exam 3	Final
Gender	β_1	–29.84	–16.66	–20.99	–46.08
	p	0.25	0.65	0.48	0.17
ACTMath	β_2	1.31	1.34	0.91	0.70
	p	<0.0001	0.004	0.0034	0.046
Gender ×*ACTMath*	β_3	0.90	0.46	0.59	1.40
	p	0.25	0.68	0.52	0.17

TABLE VI
REGRESSION MODEL RESULTS FOR ECE 290

		Exam 1	Exam 2	Final
Gender	β_1	46.20	19.39	21.76
	p	0.097	0.33	0.44
ACTMath	β_2	1.71	1.14	1.56
	p	<0.0001	<0.0001	<0.0001
Gender× *ACTMath*	β_3	–1.35	–0.52	–0.64
	p	0.12	0.41	0.47

CONCLUSION

In this study, we compared women's and men's exam scores in two core courses in computer engineering. We found that, compared with men, women do not score lower on exams. Thus, we cannot conclude that poor performance is a cause for the low retention of women in computer engineering. We also tested Dweck's findings on our population. Contrary to Dweck's findings, we did not find that entity theorists perform worse on exams than incremental theorists.

Although this research yielded unexpected results, it is important to note the number of women was small. For statistical analyses, the larger the sample size, the better the quality of the result. We considered different ways of increasing the number of women in our study by aggregating exam scores and by conducting the same surveys in multiple semesters, but none were feasible. If we had had more women, then we may have found statistically significant differences in exam scores between women and men.

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