Encouragement May Be the Missing Link in the Pursuit of CS / IT Majors

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Abstract

Few students in general, and fewer female students in particular, choose an undergraduate major in IT/CS. Efforts at ameliorating the situation must be rooted in an understanding of those factors which have a demonstrated influence on major/career choice and decision making. In an attempt to improve our understanding, we surveyed students enrolled in IT105/155, a mandatory freshman computer science course. Our findings showed that male and female students did not differ from each other in terms of their grades, self-efficacy, need for encouragement, and perceptions about the major. These findings held whether students were taught by male or female instructors. Our survey results indicated that there are three major influences on a freshman's consideration on majoring in IT/CS: receiving more encouragement to major in the field; self-efficacy after completing IT105/155; and interest in taking an IT/CS course consisting of a majority of students the same sex as themselves. These survey results will serve as the basis for follow up research aimed at identifying those kinds of encouragement that might prove helpful in assisting students in choosing to major in IT/CS.

Background

The growing concern for the future of America and her ability to remain competitive in a highly technological age has prompted much research over the number of students pursuing degrees in Science, Technology, Engineering, and Mathematics (STEM) at the undergraduate level. The problem is commonly referred to as the pipeline shrinkage problem where the ratio of women to men involved in computing shrinks from early student years to working years .[1] Much research has been conducted in an attempt to determine the reasons behind the sharp drop-off of women in the field and also to increase the number of women in computing.

The low number of women majoring in computer science has been a problem for many years. Low enrollments in computer science programs have resulted in low percentages of women in the IT workforce. The reasons for low enrollment are varied and have been widely documented .[2] Some reasons include lack of computer confidence, negative stereotypes of the field of computer science, and limited programming experience .[2]

Studies show that girls lose interest in computer science at a very early age. According to a literature review on women in computing done by the Association for Computing Machinery – Women , basic gender differences between girls and boys leave girls frustrated with computers at a very early age.[3] Also, girls are sometimes less exposed to computers. From a very early age, in a computing environment, boys take control while the girls sit back – even though they're entirely capable. Society also has a negative effect on how girls see boys depicted as computer scientists. Most depictions of computer science are not glorified in nature and negatively imply that computer science is only for geeks and nerds.

To combat the fact that girls are conditioned at a young age to let the boys take charge, schools have begun experimenting with same sex classrooms. Research has shown that environments that are all female can produce higher confidence levels in math, science, and engineering. Intimidating perceptions that boys are better in these subjects is eliminated in a same sex classroom .[4] Some schools have adopted same sex classes as a strategy to enhance the learning experience of either girls or boys with positive results for girls.[5] Could the perceptions of computer science be more positive for females in a same sex classroom?

Method

All freshmen at the United States Military Academy (USMA) are required to take IT105/IT155 regardless of their academic major. Students learn web design/programming using XHTML, Java programming using the flow charting tool Raptor, and basic IT knowledge in the one semester course. IT155 is the honors version of IT105 and is comprised of students that demonstrate proficiency in their computer skills. IT155 differs from IT105 in that students cover topics more rapidly and work additional class exercises; however, both courses have the same graded requirements.

Students are taught in sections of no more than 18 students. Sections that included female students were set to a ratio of 50/50 or close to 50/50. This high mix of females in a section was done intentionally based on prior research in that area .[4]

Results

At the end of the Spring 2010 term, 300 cadets enrolled in IT105/155 were surveyed. The survey items and associated descriptive statistics are found in Table 1.

Table 1. Descriptive Statistics

#	Item	N	Mean	SD
1	Sex of cadet *{Sex of cadet}*	300	.84	.364
2	Sex of instructor *{Sex of instructor}*	300	.79	.406
3	Were you resectioned? *{Resectioned}*	304	.46	.499
4	If resectioned, what was sex of instructor? *{Resectioned sex}*	134	.86	.350
5	Math grade *{Math grade}*	296	3.15	.738
6	IT105/155 grade *{IT105/155 grade}*	294	3.55	.598
7	Prior to taking this course, do you think you had enough computer skills to major in IT, CS, or EE? *{Pre-course Self-Efficacy}*	299	2.45	1.240
8	After completing this course, are you more likely to major in IT, CS, or EE? *{Major}*	296	2.80	1.143
9	After completing this course, do you think you are capable of being a major in IT, CS, or EE? *{Post-course Self-Efficacy}*	297	3.57	1.051
10	Do you think with more encouragement that you would be interested in IT, CS, or EE? *{Encouragement}*	283	2.44	.829
11	Do you think that professionals in the IT, CS, or EE fields mainly work alone or interact with others? *{Social}*	263	1.89	.309
12	Do you think in the future that you would be interested in an IT305 section that had a majority of students of your same gender? *{Same sex class}*	296	2.34	.786

Item 1 is coded 1 = Male and 0 = Female; thus, 84% of survey takers were male cadets.
Item 2 is coded 1 = Male and 0 = Female; thus, 79% of cadets had a male instructor.
Item 3 is coded 1 = Yes and 0 = No; thus, only 46% of cadets were resectioned.
Item 4 is coded 1 = Male and 0 = Female; thus, of those cadets who were resectioned, 86% had a male instructor.
Item 5 is the cadets' math grade on a 4-point GPA scale.
Item 6 is the cadets' IT105/155 grade on a 4-point GPA scale.
Items 7 through 9 are on a 5-point scale.
Item 10 is on a 4-point scale.
Item 11 is coded 1 = Alone and 2 = With Others.
Item 12 is on a 4-point scale.

Item 8 (*Major*) essentially serves as the outcome variable of interest; the other variables are analyzed to determine the extent of their effect on cadets' likelihood of majoring in IT/CS/EE.

Cadets at USMA are overwhelmingly male (84% of the sample) and the clear majority of them in IT105/155 are taught by male instructors (79% of the sample). Possible effects of the sex of the cadet will be examined later in this paper.

An important, and welcome, finding is that cadet self-efficacy improved markedly as a result of having taken the course (from 2.45 to 3.57 on a 5-point scale). This is an increase of 1.12 points, with a Cohen's *d* of .974, indicating a large effect.

{Note: Effect size statistics, such as Cohen's *d*, are preferred to null hypothesis significance tests and their associated *p*-values because they are not influenced by sample size and are relatively immune to violations of assumptions such as departures from normality and inequality of sample sizes [4]. Cohen suggests the following conventions for *d*: .200 - .499 = Small, .500 - .799 = Medium, and .800 and above = Large.}

A final interesting finding is that, in contrast with what most people are said to believe about IT and CS, 89% of cadets surveyed believe IT/CS to be a social enterprise (Item 11).

Table 2. Correlations

	Math grade	IT105/155 grade	Pre-course SE	Major	Post-course SE	Encouragement
Math grade	----					
IT105/155 grade	.458**	----				
Pre-course SE	.110	.156**	----			
Major	.066	.220**	.227**	----		
Post-course SE	.129*	.402**	.384**	.442**	----	
Encouragement	-.027	.055	.091	.651**	.303**	----
Same sex class	.064	.051	.159**	.169**	.019	.039

*$p < .05$; **$p < .01$

Encouragement, rather than a *Same Sex Class*, has the strongest positive effect on likelihood of choosing IT/CS/EE as a *Major* ($r = .651$ vs $r = .169$). Put another way, *Encouragement* explains about 42% of the variance in *Major* while *Same Sex Class* explains only a little less than 3% of the variance. *Post-course SE* also correlates strongly with *Major* (as expected).

Effects of Sex of Cadet on Variables

Table 3. *t*-tests of Means of Male and Female Cadets on Items

Item	Sex of cadet	N	Mean	SD	Cohen's *d*	Effect Size
Resectioned	Female	47	.21	.414	-.631	Medium
	Male	253	.50	.501		
Math grade	Female	45	3.13	.757	-.026	None
	Male	250	3.15	.738		
IT105/155 grade	Female	46	3.39	.577	-.323	Small
	Male	248	3.58	.598		
Pre-course SE	Female	47	1.96	1.083	-.504	Medium
	Male	251	2.55	1.249		
Major	Female	46	2.57	1.003	-.248	Small
	Male	250	2.84	1.163		
Post-course SE	Female	47	3.38	1.074	-.217	Small
	Male	250	3.61	1.044		
Encouragement	Female	43	2.40	.821	-.060	None
	Male	240	2.45	.832		
Social	Female	42	1.88	.328	-.063	None
	Male	221	1.90	.306		
Same sex class	Female	47	2.26	.820	-.112	None
	Male	249	2.35	.780		

The sex of the cadet is only moderately associated with two variables. Male cadets were more likely to be resectioned than were female cadets, and they had higher Pre-course Self-Efficacy. Interestingly, both sexes view IT/CS/EE as being primarily a social, rather than an isolated, profession (and they did not differ from each other in that view). Also, male and female cadets are virtually indistinguishable in their slight preference for a same sex class.

Effects of Sex of Instructor on Variables

Table 4. *t*-tests of Means of Cadets in Classes Taught by Male and Female Intructors

Item	Sex of instructor	N	Mean	SD	Cohen's *d*	Effect Size
Resectioned	Female	62	.27	.450	-.483	Nearly Med
	Male	238	.50	.501		
Math grade	Female	60	2.98	.792	-.277	Small
	Male	235	3.19	.721		
IT105/155 grade	Female	62	3.48	.593	-.151	None
	Male	232	3.57	.599		
Pre-course SE	Female	62	2.31	1.182	-.147	None
	Male	236	2.49	1.256		
Major	Female	61	2.80	1.077	.000	None
	Male	235	2.80	1.161		
Post-course SE	Female	62	3.40	1.047	-.209	Small
	Male	235	3.62	1.049		
Encouragement	Female	60	2.63	.780	-.297	Small
	Male	223	2.39	.835		
Social	Female	56	1.89	.312	.000	None
	Male	207	1.89	.309		
Same sex class	Female	62	2.34	.829	.000	None
	Male	234	2.34	.776		

The sex of the instructor had very little effect on any of the variables, with one exception. Resectioned cadets were more likely to have had a Male instructor by a Nearly Medium amount. (This is to be expected as most instructors are male.)

Multiple Linear Regression

The outcome variable (*Major*) is regressed on the several predictor variables found in the correlation matrix in Table 1. Not all predictor variables are shown to be significant. Those statistically insignificant variables are dropped from the analysis and the regression is rerun. The final results indicate the presence of three significant predictor variables. The results are shown in Tables 5-7.

Table 5. Model Summary

Model	R	R^2	Adjusted R^2	Std. Error of the Estimate
1	.698[a]	.487	.482	.800

a. Predictors: (Constant), Same sex class, Post-course SE, Encouragement

The model is quite strong, with very nearly half the variance in the outcome variable explained (48.2%).

Table 6. ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	166.460	3	55.487	86.771	.000[a]
	Residual	175.212	274	.639		
	Total	341.673	277			

a. Predictors: (Constant), Same sex class, Post-course SE, Encouragement

b. Dependent Variable: After completing this course, are you more likely to major in Information Technology, Computer Science, or Electrical Engineering?

A significant ANOVA suggests that the predictors are making a significant contribution.

Table 7. Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	-.453	.239		-1.894	.059
	Post-course SE	.242	.048	.229	5.018	.000
	Encouragement	.774	.061	.575	12.623	.000
	Same sex class	.185	.061	.131	3.025	.003

a. Dependent Variable: After completing this course, are you more likely to major in Information Technology, Computer Science, or Electrical Engineering?

The three remaining variables all contribute significantly to the outcome variable. Encouragement is by far the strongest contributor.

Discussion

Table 8. Summary of Effects of Sex of Cadet and Sex of Instructor on Variables

Variable	Sex of Cadet	Sex of Instructor
IT105/155 grade	*Male*	None
Post-course SE	*Male*	*Male*
Social	None	None
Encouragement	None	*Male*
Major	*Male*	None

Male indicates a superior score, as determined by the Cohen's *d* effect size statistic, for either male cadets or those cadets taught by a male instructor (depending on the column).

Results from Tables 3 and 4 for five important variables are summarized in Table 8. The literature in CS education references two main findings or assertions: one, that men tend to outperform or outscore women; and two, that the sex of the instructor can have a profound effect on scores and outcomes. These are only partially supported in our study. Male cadets did outscore their female counterparts in IT105/155 course grade, indicate a higher Post-course Self-Efficacy, and express a greater likelihood of majoring in IT, CS, or EE; however, they were no more likely than were female cadets to view IT/CS as a social enterprise, nor were they more likely to admit that encouragement would have a positive effect on their interest in IT/CS/EE.

The sex of the instructor had no effect on the IT105/155 course grade, cadet perceptions of IT/CS as a social enterprise, or on cadet likelihood of majoring in IT, CS, or EE. There was, however, an effect on Post-course Self-Efficacy and on admitting that encouragement would have a positive effect on their interest in IT/CS/EE (male instructors have positive effects on both variables).

The mixed and varied nature of the results are perhaps an artifact of the unique population which comprises USMA's Corps of Cadets; these students typically score higher than other college undergraduates on a host of physical, intellectual, moral, and other tests and surveys. Additionally, the Corps is predominantly male (as compared with most college campuses which are majority female).

A welcome finding is the result of the regression (Tables 5-7). By a large margin, cadets of both sexes indicated that encouragement to major in IT/CS/EE might prove to be adequate to move them in that direction. Post-course self-efficacy does not have the same effect (positive, but weaker), and taking a same-sex class contributes the least of the three to the decision.

Conclusion

Cadets are self-reportedly amenable to considering majoring in IT/CS/EE. Encouragement to do so is the major factor which would improve this likelihood. Self-efficacy, the belief that one is capable of performing an activity, accomplishing a task, or attaining a goal, also has a strong influence. The fact that it is *post*-course, rather than *pre*-course SE, which has an effect on likelihood of majoring in IT/CS/EE, is welcome news; it implies that what happens in an introductory survey course can have a positive effect on choice. Finally, both male and female cadets are somewhat open to the idea of having a class consisting entirely of cadets of the same sex. Further investigations, both quantitative and qualitative, are warranted.

Future Work

Our future research will focus on better understanding encouragement. What forms of encouragement are needed? Are there sex effects on the types of encouragement; that is, might it be the case that certain kinds of encouragement affect men and women differently? We will be examining these and other questions (such as the generalizability of the findings to the national collegiate population) in upcoming research.

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