Alternate Pathways To Success

Donna Llewellyn[1], Marion Usselman[2], Monica Gaughan[3]
[1]Center for the Enhancement of Teaching and Learning (CETL)/
[2]Center for Education Integrating Science, Math, and Computing (CEISMC)/
[3]School of Public Policy
Georgia Institute of Technology

Introduction

In order for universities to design information technology (IT) programs that accommodate diverse demographic populations, it is important to understand the educational and career achievement strategies used by different groups of IT professionals—white men, minority men, white women, and minority women—and to design educational requirements that accommodate these different strategies or educational pathways. Our NSF-funded *Alternate Pathways to Success in Information Technology (APSIT*)* program is seeking to explore the nature of the IT and engineering educational and career pathways used by successful female and minority Georgia Tech alumni. In particular, the specific goals of this project are:

- To define alternate indices of IT and engineering success that reflect a broader interpretation of societal value than indicated by yearly income and job prestige.
- To determine the nature of successful IT and engineering educational and career pathways used by women and other under-represented populations.
- To compare the educational and career pathways exhibited by IT and different fields of engineering to determine the causes of differential attractiveness of fields to different population subgroups.

Human Capital and Occupational Choice

In the literature on occupational choice and human capital the predominant assumption is that individuals choose to make investments in their education on the basis of the expected earnings and prestige of the employment accessible due to that training. Individuals are likely to choose among the pool of accessible occupations the ones that are most likely to maximize the return on investment in their human capital[1,2]. Occupational attainment has been extensively investigated as a function of individual stratification variables, family background, 'human capital' (measured in terms of experience, training, knowledge etc.), costs to undertake education, and expected rewards[3,4]. For example, Boskin (1974)[5] confirms three hypotheses: that workers choose occupations that (1) maximize the discounted present value of potential lifetime earnings, (2)

* National Science Foundation (NSF) Award no. 0204316.

entail the lowest training costs, and (3) offer the lowest discounted present value of expected earnings foregone due to unemployment.

It seems plausible to assume that many more particular attributes of occupations affect professional choice decisions. These might be variables such as work environment, work style, time flexibility, discrimination, job complexity, and type of benefits. If the choice set of professional opportunities is similar and examined only on rewards or prestige grounds, the impact of these additional variables on the decision will remain unknown. On the other hand, there may be many more constraints to entering certain professions because of stratification constraints such as educational level attained, parent's education, and race. Such variables may include the presence or absence of fixed career paths, necessity or availability of on-the-job training, availability of codified and tacit knowledge, and transferability of skills.

In particular, race, ethnicity, and gender are stratification factors that affect professions and choices to enter them. Hull and Nelson (2000)[6] offer a broad treatment of the gender differences in career trajectories. Using the case of lawyers' careers, their study tests competing hypotheses derived from three broad theoretical models of gender differences in professional careers: assimilation, choice, and constraint. Men and women begin their careers in different contexts, the authors argue, and these differences grow over time in terms of career path, career position, and career opportunity.

Gender and race dynamics should therefore not be underestimated in investigating the determinants of career decisions and trajectories. Nielsen et al (2001)[7] noted that even though the proportion of female and minority professionals in science and engineering is increasing, this increase is not found in the IT sectors. As far as the under-representation of women in IT is concerned, they attribute an important role to 'cultural factors' such as the male dominated, geeky culture in IT programs and workplaces that sometimes results in ignoring and even harassing women aspiring to such positions.

Computing and Engineering Education

Racial, ethnic, and gender stratification begins early in scientific and technical educational trajectories. The AAUW claims that technological careers will increasingly draw on the humanities, social science, and people skills. There is indeed anecdotal evidence that women are likely to enter the IT workforce from paths that are quite different from the ones taken by their male counterparts[8,9,10]. It is also very clear that different technical disciplines differentially attract women and minorities. The disciplines most closely aligned with the IT workplace, namely Computer Science, Computer and Electrical Engineering, appear to be particularly unattractive to white women, but not to African American or Asian women[11],[12]. Freeman and Aspray conclude that if the number of women in the IT workforce were increased to equal the number of men, the tremendous shortages of IT workers noted in the ITAA studies could be filled. However, according to the Department of Commerce, only 1.1 percent of undergraduate women choose IT-related disciplines as compared to 3.3 percent of male undergraduates[9].

Why has the field of computer science and engineering continued to be overwhelmingly the domain of white and Asian males? Computer Science and Engineering education programs similarly have a reputation of encouraging a white male-dominated culture that many women and minorities find hard to penetrate[13,14,15,16,17,18]. Often even the language used by the students reflects this culture[19]. For example, in a talk at the 2001 SIGCSE conference, Manda Wilson described why she studied computer science in college. While the unexpected creative nature of her computing courses was a major motivator, she was almost frightened off by the male hackers in the introductory class.

While mathematics is also often seen as a male field, there is not a pervasive male math language that is comparable to the male computer science hacker language. Are there differences in the ways that groups of students respond to the dictates of these traditional high-powered IT and engineering educational programs? These programs generally require that students enroll in the related degree program from the beginning of their college career and take a defined, and very challenging, set of technical courses with little room for individual variation. Programs that require such a lock-step adherence to a set course pattern and order assume that all students arrive at the university with similar backgrounds and inclinations. Students interested in exploring a broader education, including perhaps some history, literature, or music, are effectively eliminated from the pool of viable computer scientists and engineers because of the educational path they must traverse to gain their degree. Several studies suggest that women, more than men, leave SEM not because they dislike SEM, but because they wish to pursue a broader range of academic interests[20,21,22]. Similarly, students from lower socio-economic level high schools may find that there is no opportunity for easing more slowly into the rigorous technical curriculum, a strategy that might give them a better chance for long-term success. Comfort is an important indicator for success in the first CS course[23].

Flexibility in degree paths would appear crucial for attracting a diverse population of IT professionals, but is generally not encouraged in traditional colleges of engineering, nor in newer colleges or departments of computer science. The higher educational system needs to provide a variety of training paths to IT careers. The system will be successful to the extent that it can accommodate students who have different interests, educational and vocational objectives, levels of technical ability and preparedness, and levels of self-confidence in their path to an IT career. By making the field more open to students with different objectives, backgrounds, and confidence levels, the field is more likely to attract students of all kinds[9]. Many engineering, computer science, and mathematics students, faculty, and teaching assistants are strongly resistant to collaboration evidence[24]. "Women in engineering programs are kind of like canaries in the coal mine," testifies Stephen W. Director, Chair of the Engineering Dean's Council. If women do well in a program, most likely everyone else will also do well in the same type of program[25].

Computing and Engineering Careers

Greater difficulty in the technical educational path also persists for women and minorities into the career trajectory. A study of 300 women engineering graduates from Northeastern University indicates that the challenging nature of engineering work and the high financial rewards result in a large degree of job satisfaction among women engineers[26]. Only 6% of the respondents indicated that they were not glad they decided to become an engineer. However more women than men left their engineering jobs, due chiefly to difficulty with balancing career and family responsibilities and to the male-dominated nature of the workplace.

These experiences vary greatly depending upon the employer and company attitudes towards issues such as flexible work schedules and whether women were provided with adequate mentoring and included in the male-dominated upwardly mobile colleague loop. These barriers to advancement for women and persons of color in engineering careers therefore appear to be of a structural nature and not inherent to the engineering field. Women do not drop out because they dislike engineering. They drop out because of lack of job flexibility and because of an overwhelmingly white-male culture.

What is Success?

The different kinds of problems and motivations faced by minorities and women also translate into different conceptualizations of positive and negative outcomes in the technical career. Statistics related to success of women and minorities in professional SEM careers can often be misleading due to the use of narrow definitions of success. The means by which students of color and women fulfill their academic promise may differ systematically from the path taken by white males[11, 12]. Although standard indices of success (primarily yearly income and job prestige) may suggest underachievement, these studies find that African Americans and Latinos contribute more to their communities through service activities than do their Anglo peers. In addition, women who choose part-time work to help balance career and family can be highly productive but are inevitably classified as adult underachievers. In neither of these cases do the successful women or people of color fit the criterion for success dictated by a white-male culture.

The differential ability of women to balance work and family in light of a complementary marriage system has been well documented [27,28,29]. The result of the family-career conflict is that career trajectories of women often follow different patterns than those of men[30]. Failure to account for these differing patterns hampers our understanding of women's careers, one issue to be addressed in this study.

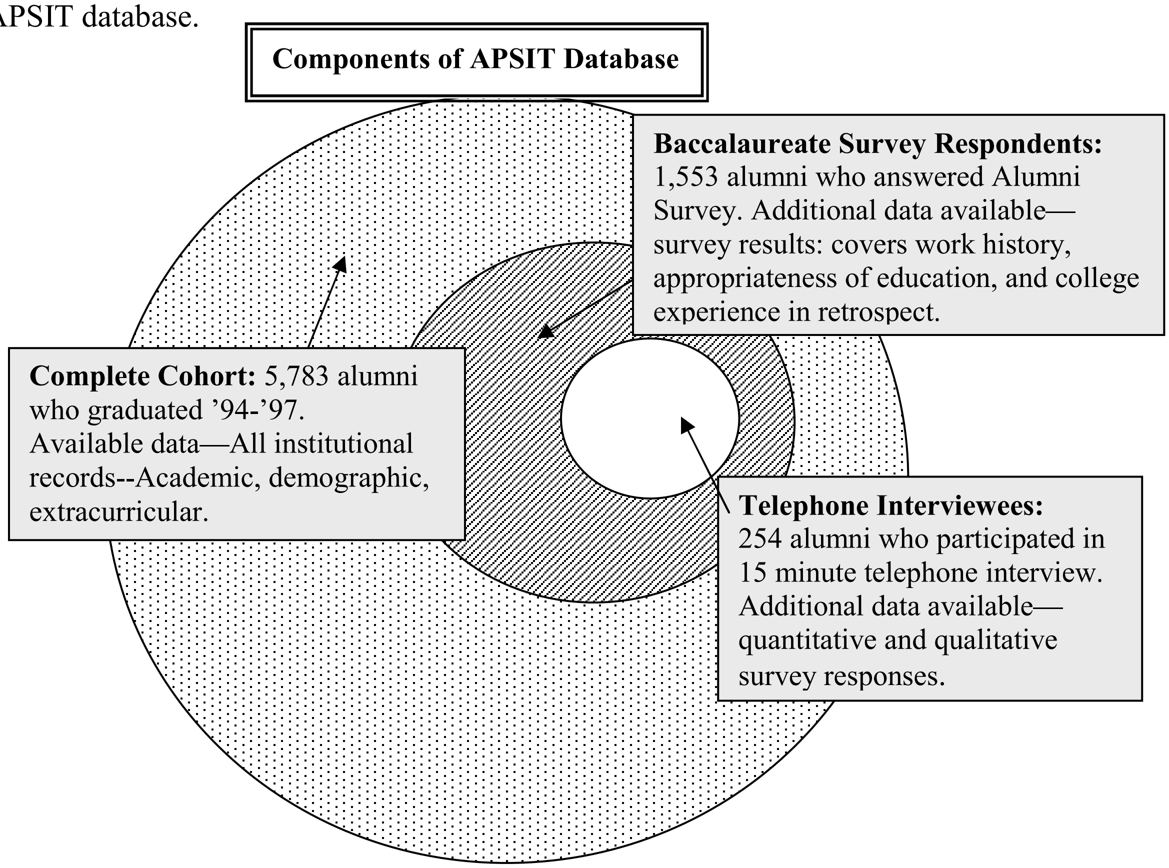
Because of race and sex differences, professional choice cannot be fully addressed through current occupational choice theories. In this paper, we address the problem of gender and race dynamics in Information Technology-related fields. This study evaluates the distribution of family-background, educational, family, and employment characteristics by gender and race. We use these characteristics to evaluate the determinants of job satisfaction among highly educated IT-eligible workers.

Data and analysis

Georgia Tech is the only institution that ranks in the top 10 in graduating women and minorities in all engineering degree categories--bachelors, masters, and doctorate. Because of its specialization in technical education, Georgia Tech's extensive alumni database provides a unique resource for studying the pathways blazed by successful female and minority IT professionals and engineers. The advantages of studying this elite group, who do not represent the general population, are far outweighed by the design strengths offered by the rich panel data. Additionally, it is not unreasonable to suggest that the IT experiences of elite underrepresented gender and racial minorities constitute the best-case scenarios for attracting talent to the IT field. What we can learn from them will be theoretically relevant to less elite educational groups. Work to date has progressed along several separate, but linked, directions—1) developing a comprehensive database, 2) designing, testing, and then conducting a telephone interview protocol, and 3) defining research questions and database queries.

The first component was to develop a comprehensive and clean database that contains all the available institutional records on academic performance and individual demographics of the cohort of 5,783 Georgia Tech alumni who graduated from 1994-1997. This work was done primarily by staff in the Georgia Tech Office of Minority Educational Development (OMED). In addition, during the summer of 2003, two high school mathematics teachers who were hired through NSF's Research Experience for Teachers program worked with a graduate student from Industrial and Systems Engineering to help create the database using Microsoft Access. The database was then linked, using a randomized ID number, to the subgroup of 1,553 alumni who returned a Georgia Tech Office of Assessment Baccalaureate Survey administered in October 2001. Of this subgroup, 1,262 agreed to be contacted as part of a telephone survey for the APSIT project.

We utilized various sources, including the Georgia Tech Alumni Association and Office of Assessment, Experian, and whitepages.com, to obtain current telephone numbers for the group of alumni who agreed to be interviewed. Through these sources we obtained 1,101 potential phone numbers, 69% of which successfully led to either the appropriate person or their answering machine. Data fields for all phone interviews are now being linked to the appropriate institutional records and Baccalaureate Survey responses. The graphic below details the final APSIT database.



The Telephone Survey

During the winter and spring of 2003, the telephone survey was developed and piloted by graduate students and faculty in the School of Public Policy, and other APSIT staff. The survey contains a mix of formal, closed-ended questions and open, qualitative ones, and explores the nature of the person's general work experience, their experience with information technology and the IT workplace, and their definition of personal and professional "success". Since all Georgia Tech undergraduate students, regardless of major, are required to take a course in computer programming, all alumni are qualified, in a broad sense, to participate in the IT workforce. One section of the survey therefore explores participants' perspectives of what the description "being in the IT workforce" actually means.

During the summer of 2003, two Public Policy graduate students employed by APSIT, two high school teachers participating in an NSF-supported Research Experience for Teachers (RET) program, and two undergraduate students participating in an NSF Research Experience for Undergraduates (REU) program called all 1,101-phone numbers at least once. Valid phone numbers were each called five times, with messages left on the answering machines. Of the 736 valid phone numbers, 254 resulted in completed phone interviews, for a response rate of 35%. In 380 cases, messages left on answering machines were never returned and contact was never made. Only 30 people who were contacted, or 4% of the total, refused to participate in the survey. Particular effort was made to contact all women and underrepresented minorities in the database. Of the 254 successful interviewees, 91 (35.8%) were women, and 31 (12.2%) were underrepresented minorities.

Our Research Strategy

Because of the complexity of the APSIT database, research questions must be defined carefully to ensure that queries are not prohibitively labor intensive. The structure of the database itself was created in tandem with the research questions so as to ensure that all necessary fields were included and accurate. The APSIT research questions have been defined to take advantage of the different levels of data available, ranging from institutional records of incoming academic qualifications and subsequent college academic performance, to qualitative answers of open-ended questions regarding reasons for job satisfaction and dissatisfaction.

We use the institutional records to explore the academic pathways and strategies that various demographic groups use when navigating their way through the Institute. How well do students from different backgrounds succeed in the core science and computing requirements? How do the incoming academic qualifications vary by demographic subgroup and how does this affect their later college education?

We combine the institutional data with the telephone survey data to define questions that relate to IT workforce development. Questions include: How differently do men and women perceive their workplace environment, and which factors most affect these perceptions? How do technically literate professionals define the "IT workforce", and how does this correlate with actual job activities?

Results

The results presented here are based on the institutional records and closed-ended quantitative measures from the telephone survey instrument. Our overall approach is to develop and analyze measures that will allow us to identify the respondent's formative family experiences, their current computer and work orientations, their overall IT skill set, current family structure, and general employment experiences. In this way, we are beginning to construct life trajectories that begin in a respondent's family of origin, and extend through educational experiences and work outcomes.

In addition to categorical and ordinal variables, which we use directly, we create several additive scales to represent our constructs of interest. First, we develop two scales to assess computer intensity in the respondent's career. This measure therefore excludes the 26 respondents who are not currently employed; indeed, this study focuses as a whole only on the currently employed. The Technological Complexity measure taps the range of high-level computer-intensive work functions the respondent uses in a typical week. It has a good alpha reliability of .78. The Computer Application measure assesses the extent of the respondent's familiarity with specific computer applications. Its alpha reliability is .79.

We also assess more general work characteristics. The Work Complexity measure gives the range of high-level work functions the respondent performs in a typical week. Its alpha reliability of .65 indicates that more work on its measurement reliability is warranted. This will be pursued in later work. For now, the measure is a crude index of the range of high-level functions respondents perform. Job Satisfaction is developed from Likert scales of satisfaction, and its reliability is .71. This measure will also need additional work on its reliability; in particular, the item assessing ability to combine work and family should probably be excluded. Finally, Adequacy of Benefits assesses the degree to which respondents are satisfied with various benefits offered by their employer. We purposely incorporated benefits that would be generally of greater interest to women, given a traditional conceptualization of women's family roles. Its alpha reliability is .80.

Characteristics

Tables 1 through 4 report the mean responses for the respondents in the first two columns. The middle columns show the same characteristics by gender, and the last two columns evaluate the measures by race (separated here by White and Non-white (which includes Asian respondents)). We begin by describing the univariate patterns in family background (Table 1). Consistent with the high socioeconomic status of our respondent's families, the typical father has a college degree, while the typical mother has at least some college education. In general, the distribution is skewed toward the high end of educational achievement. Our respondents were very able students, averaging 1209 on the old version of the SAT. Twenty-nine of our responses have missing SAT scores and these are eliminated from the analysis. The average age at first computer use is 12, but the range is from 5 to age 30. The average respondent decided on his or her career during undergraduate studies.

Table 1: Background Characteristics, by Sex and Race

	Range	Mean	Men n=161	Women n=90		White n=205	Nonwhite N=46	
Mother's Education*	0-6	3.71	3.65	3.82		3.74	3.59	
Father's Education*	0-6	4.15	4.09	4.27		4.17	4.07	
Decide on Career**	1-8	3.17	3.32	2.91	sig.	3.13	3.37	
SAT Verbal	530-780	549	542	562		558	507	sig.
SAT Math	340-790	660	668	647	sig.	666	632	sig.
Age at 1st Computer Use	5-30	12.22	12.16	12.33		12.14	12.6	

sig. = significant difference at .05 level or better, two-tailed t-test
*0 = Less than HS, 1 = Some HS, 2 = HS, 3 = Some College, 4 = College degree, 5 = Some graduate school, 6 = Graduate or professional degree
**1 = Prior to HS, 2 = During HS, 3 = During UG, 4 = During college job, 5 = After highest degree, 6 = During first post-graduate job, 7 = During subsequent job, 8 = other.

Turning next to Computer Orientations (Table 2), we find one-third of our sample self-identifies as an IT professional. Of those who are currently an IT professional, 10% held an earlier IT position. Of those not in the IT profession, 20% have considered, but not pursed, IT work. The respondents—IT and not—spend almost three-quarters of their time at work on a computer. In general, they are relatively experienced with a wide variety of computer applications; however, the typical job requires only 3 high-level computer work functions.

Table 2: Computer Orientations, by Sex and Race

	Range	Mean	Men n=159	Women n=89		White n=203	Nonwhite n=45	
Technological Complexity	0-10	2.98	3.06	2.82		2.98	2.98	
Computer Applications	10-38	20.11	20.59	19.24		19.79	21.53	
% Time at Work on Computer	0-100	73.9	72.79	76.18		71.48	85.12	sig
Information Technology Worker	0-1	0.31	0.29	0.33		0.29	0.4	
Prior IT Work (n=177)	0-1	0.1	0.09	0.11		0.1	0.08	
Ever Consider IT Work (n=166)	0-1	0.19	0.25	0.08	sig.	0.19	0.19	

sig. = significant difference at .05 level or better, two-tailed t-test

Almost three out of four respondents is married, and 41% have children. Their spouses tend to have a high level of education, averaging at the graduate school level. Only 50 respondents have children under the age of 11. Of these respondents, 90% rely on their spouse for childcare.

Table 3: Current Family Status, by Sex and Race

	Range	Mean	Men n=160	Women n=90		White n=205	Nonwhite n=46	
Married	0-1	0.73	0.71	0.78		0.78	0.53	sig
Spouse Education Level*	1-5	3.58	3.4	3.9	sig	3.58	3.6	
Any Children	0-1	0.41	3.9	4.6		0.45	0.26	sig
Childcare by spouse (n=50)	0-1	0.9	0.95	0.57	sig	0.93	0.67	

sig. = significant difference at .05 level or better, two-tailed t-test
*1 = HS, 2 = Some college, 3 = College Degree, 4 = Some graduate school, 5 = Graduate or professional degree

In terms of current work experiences, respondents experience a median level of work complexity, tend to be highly satisfied on their jobs, and are only somewhat satisfied with the adequacy of benefits. The typical respondent has not experienced discrimination on the job, rarely feels excluded from an in-group, and sometimes has trouble balancing work and family. Respondents sometimes enjoy mentoring at work.

Table 4: Employment Experiences, by Sex and Race

	Range	Mean	Men n=163	Women n=91		White n=208	Nonwhite n=46	
Work Complexity	0-10	5.29	5.31	5.26		5.42	4.69	
Job Satisfaction*	10-24	18.36	18.2	18.71		18.58	17.35	sig
Adequacy of Benefits**	0-20	11.12	12.11	9.34	sig	11.08	11.28	
Discrimination on the Job**	1-4	1.22	1.16	1.35	sig	1.15	1.53	sig
Mentor***	1-4	2.87	2.96	2.67		2.9	2.75	
Work-Family Balance Trouble***	1-4	2.37	2.37	2.37		2.42	2.13	
Feel Excluded from In-Group***	1-4	1.54	1.57	1.46		1.5	1.7	

sig. = significant difference at .05 level or better, two-tailed t-test

*This is an additive result of 6 questions each on a 4 point scale with 1 = not satisfied and 4 = satisfied

**This is an additive result of 5 questions each on a 4 point scale as above

***These are questions on a 4 point scale with 1 = never experienced and 4 = experienced frequently

Gender Dynamics

Referring back to Tables 1 through 4, we now turn our attention to the middle columns, which explore gender differences. There is only one family background characteristic on which men and women differed. Men typically decide on their careers in college or later, while the women typically decided on their careers while still in high school. In terms of computer skills and orientations, men and women are similar, except that women are significantly less likely to consider pursuing a career in IT (Figure 1). This is interesting because the women are as experienced with various computer applications, spend as much time working on a computer, and have the same level of technological complexity in their positions. This reinforces the idea that it is not a lack of preparation or ability, but a lack of desire that keeps women from entering IT professions.

Men and women have similar employment experiences, with two noteworthy exceptions. Women are significantly more dissatisfied with the adequacy of benefits on their job (Figure 2). They are also significantly more likely to report having been discriminated against in their current position. As would be expected in the general population, women are married to better-educated spouses than their male peers. The men are significantly more likely than the women to have their children cared for by a spouse during working hours - almost two-thirds of the women have a spouse caring for their children, compared with 95% of the men (Figure 3). It is important to note, however, that only 7 of the women have children under 11, while 43 of the men have dependent children who require intensive care. There appear to be dynamics between family care and benefit adequacy that are worthy of further analysis.

Figure 1: Proportion of respondent who ever considered an IT career, by gender and race

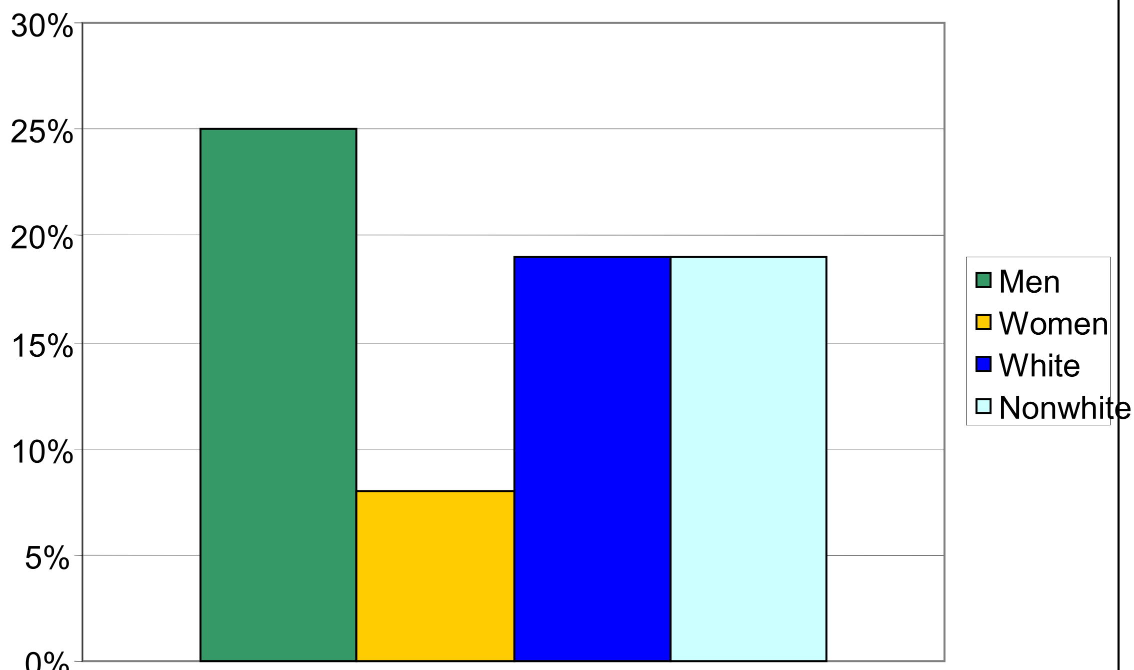


Figure 2: Adequacy of benefits by gender and race

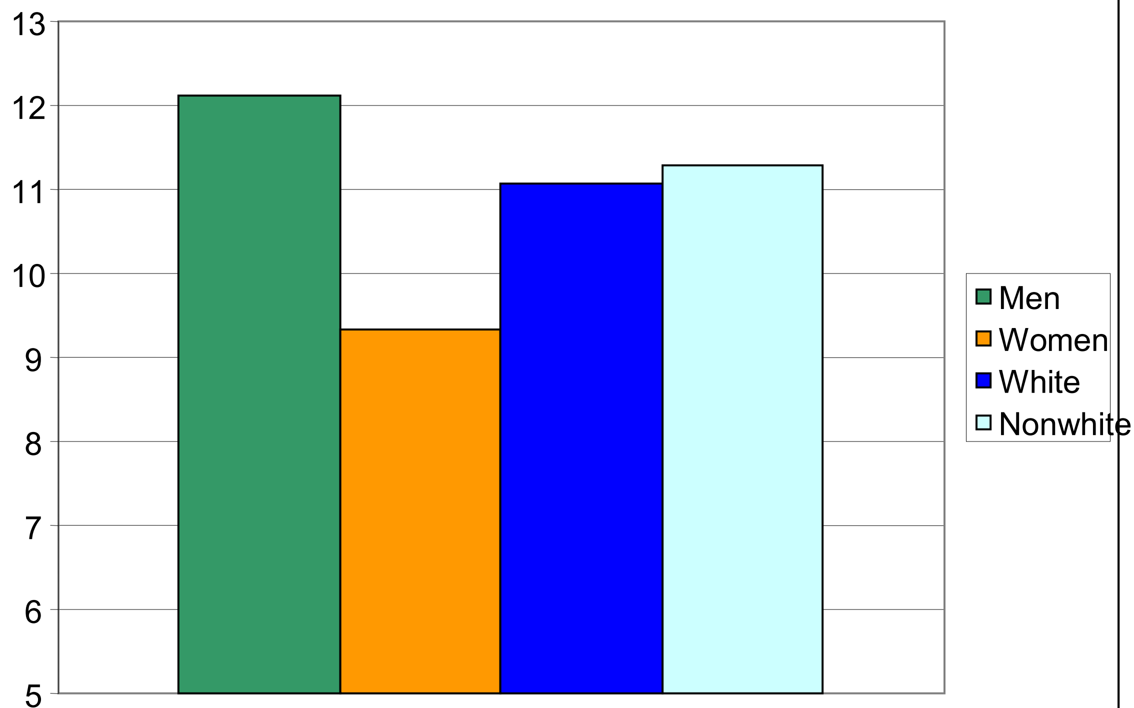
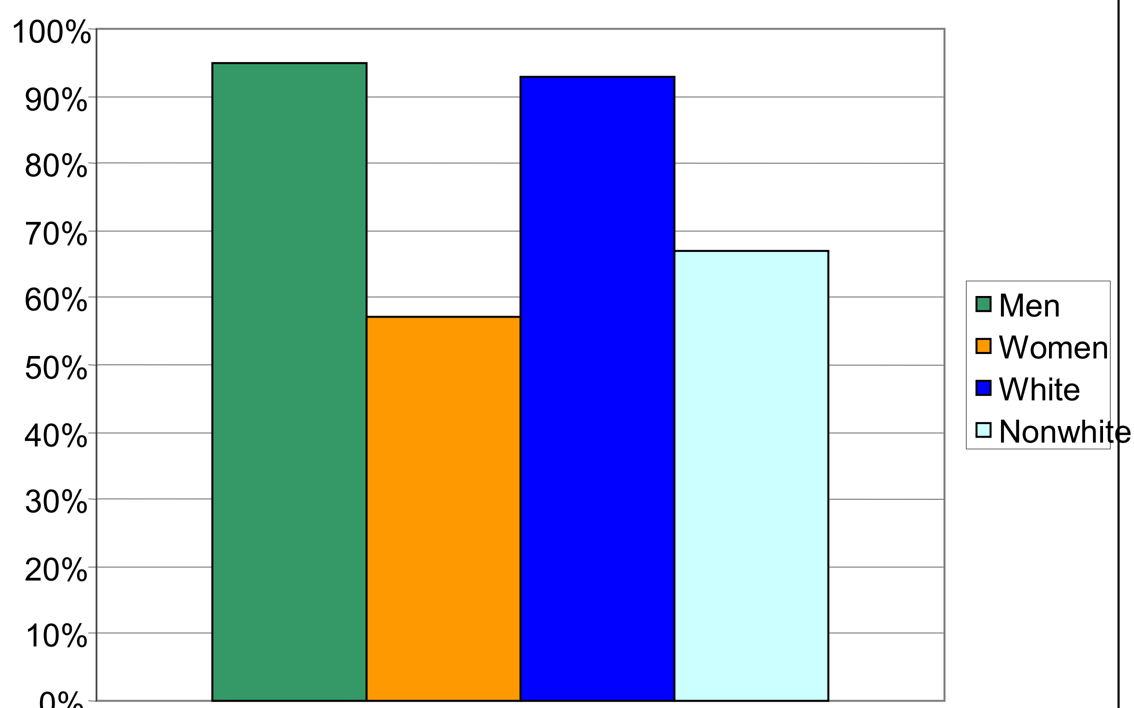


Figure 3: Childcare by spouse by gender and race

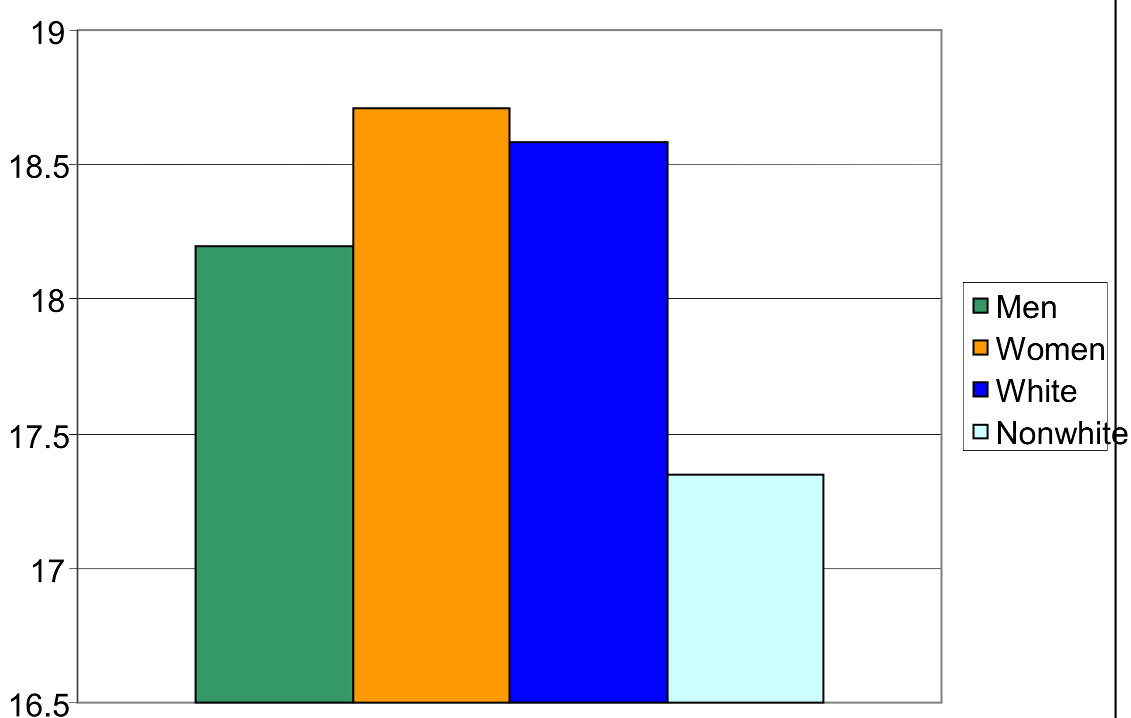


Racial/Ethnic Dynamics

The last columns of Tables 1 through 4 report racial/ethnic differences. As with gender, there are few family background differences between whites and nonwhites in this sample. Nonwhites have significantly lower verbal scores on the SAT. As with men and women, all groups experience a similar level of technological complexity and familiarity with computer applications. Propensity to enter an information technology career does not differ by racial/ethnic group. The only difference is that nonwhite respondents tend to spend significantly more time on the computer while at work.

On the job, nonwhites are significantly less satisfied than their white peers (Figure 4). As is true for women, they are also significantly more likely to report being discriminated against at their job. In terms of current family structure, nonwhites are significantly less likely to be married, or to have children. This may explain why non-whites tend not to report dissatisfaction with the adequacy of benefits, since those questions were targeted to family-related concerns.

Figure 4: Job satisfaction by gender and race



Toward a trajectory analysis

Table 5 provides an example of the types of analyses that can be pursued with this longitudinal data set. The dependent variable is the job satisfaction scale. Despite some significant differences at the bivariate level, gender and race/ethnicity do not have a significant impact on job satisfaction when controlling for other covariates. While father's education level has no impact on job satisfaction, more educated mothers tend to be associated with less satisfied workers. This is an interesting result that should be investigated further. Respondents with higher Verbal SAT score are more satisfied (Math SAT works the same way, but the two are collinear and cannot be incorporated into the same model). Of great interest to these authors is the finding that IT workers are significantly less likely to be satisfied on the job than others. This may be due to the "IT bubble burst," or it may be intrinsic to the nature of the job. Future research will explore this. Finally, satisfaction with benefits is a significant predictor of job satisfaction. Indeed, satisfaction with benefits is one reason why gender is not a predictor in multivariate analysis.

This analysis is an Ordinary Least Squares (OLS) regression on job satisfaction[31]. It should be noted, however, that there are a variety of potential dependent variables to assess job success and experiences. Furthermore, the longitudinal nature of the data will also lend itself well to panel analytic techniques to allow better assessment of causal priority issues [32,33,34]. Finally, the existence of extensive qualitative measures will also assist us in understanding how these respondents conceptualize work success and satisfaction, in and out of information technology careers.

Table 5: Ordinary Least Squares Regression on Job Satisfaction

		B	SE	sig
Demographic				
	Male	-0.73	0.45	
	White	0.64	0.55	
Family Background				
	Mother's Education	-0.42*	0.15	sig
	Father's Education	0.14	0.15	
	Verbal SAT	0.003*	0.001	sig
Information Technology				
	IT Worker	-0.91*	0.45	sig
	% Time on Computer	-0.01	0.01	
Work Experiences				
	Benefits	0.23*	0.06	sig
	Discrimination	-0.40	0.4	
Intercept		16.33		
R^2		.16		

sig.* = significant difference at .05 level or better, two-tailed t-test

Future Work

We still have a lot of work to do analyzing the rich data that have been collected. There are many research questions that we are interested in answering and analysis will continue through the next year. One important task that remains is investigating response bias. Due to the nature of our database, we have a lot of information about the non-responders at each stage. The Georgia Tech Office of Assessment has already done an analysis that shows that the people who responded to the alumni survey are representative of their cohort. For the non-responders for our telephone survey, we have all of their alumni survey data as well as the data from their institutional records. Therefore, we will be able to ascertain if the results from the telephone survey are representative of the whole cohort, and if not, we will be able to identify the extent of potential biases in this sample.

References

[1]Becker, G. S. (1964). Human capital; a theoretical and empirical analysis, with special reference to education, distributed by Columbia University Press.

[2] Schultz, T. W. (1970). Investment in human capital; the role of education and of research. New York,, Free Press.

[3] Behrman, Jere R, and Taubman, Paul, (May 1976) "The Intergenerational Correlation between Children's Adult Earnings and Their Parents' Income: Result from the Michigan Panel Survey of Income Dynamics," Review of Income and Wealth, Vol. 36, No. 2, 115-27

[4] Solon, Gary, (June 1992) "Intergenerational Income Mobility in the United States," American Economic Review, Vol. 82, No. 3, 393-408

[5] Boskin, Michael J., (1974) "A Conditional Logit Model of Occupational Choice," Journal of Political Economy, Vol. 82, No. 2, Part 1, 389-398.

[6] Hull, Kathleen, & Nelson, Robert L. (2000). Assimilation, Choice, or Constraint? Testing Theories of Gender Differences in the Careers of Lawyers. Social Forces 79 (1), 229-263

[7] Nielsen, Sue, & von Hellens, Liisa, & Wong, Sharon (2001, December 5-7) The Male IT Domain: You've Got to Be In It To WinIT! Paper presented at the 12th Australasian Conference on Information Systems, Coffs Harbour, NSW.

[8] American Association of University Women Educational Foundation. Tech-Savvy: Educating Girls in the New Computer Age, 2000 .

[9] Freeman, P. & Aspray, W., The Supply of Information Technology Workers in the United States, Computing Research Association, 1999.

[10] Widnall, Sheila E., .Digits of Pi: Barriers and Enablers for Women in Engineering., The Bridge, 30 # 3&4.Fall/Winter 2000 National Academy of Engineering.

[11] Llewellyn, D. & Usselman, M., Electricity and Computers: Which Girls Care? A Study of Georgia Tech Application Demographics., ASEE Annual Conference presentation, June 2000.

[12] Usselman, M., & Llewellyn, D., Ethnic Differences in Female Applicants to Engineering and Information Technology Majors Research panel entitled Research to Realization: Increasing Women's Participation in Science, Engineering, Mathematics, and Technology. American Educational Research Association meeting, April 2001.

[13] Arnold, Karen D. The Fulfillment of Promise: Minority Valedictorians and Salutatorians. The Review of Higher Education 16, No. 3 , Spring 1993. Pp. 257-283.

[14] Bowen, William G., and Derek Bok. The Shape of the River. Princeton University Press, Princeton, NJ 1998.

[15] Hacker, Sally. 1981. The culture of engineering: Woman, workplace, and machine. Women.s Studies International Quarterly, 4, pp. 341-53

[16] MacKenzie, D. & Wajcman, J. 1985. The Social Shaping of Technology. Milton Keynes: Open University Press.

[17] Rosser, S.V., Teaching the Majority: Breaking the Gender Barrier in Science, Mathematics, and Engineering, Teacher College Press, Columbia University, 1995

[18] Rosser, S.V. (1997). Re-engineering Female Friendly Science. New York: Teachers College Press, Columbia University.

[19] Pfleeger, S.L., Teller, P., Castaneda, S.E., Wilson, M., and Lindley, R. .Increasing the enrollment of women in computer science,. In R. McCauley and J. Gersting (Eds.), The Proceedings of the Thirty-second SIGCSE Technical Symposium on Computer Science Education (pp. 386-387). New York: ACM Press, 2001

[20] Astin, H. & Sax, L. (1996) Developing scientific talent in undergraduate women. In C. S. Davis, A.B. Ginorio, C.S. Hollenshead, B.B. Lazarus, P.M. Rayman, & Associates (Eds.), The equity equation: Fostering the advancement of women in the sciences, mathematics, and engineering. (pp. 96-121) San Francisco: Jossey-Bass.

[21] Daniels, J. and LeBold, W. (1982). Women in engineering: A dynamic approach.. In S. Humphreys (Ed.), Women and minorities in science. AAAS Selected Symposia Series.   Boulder, CO: Westview Press.

[22] Seymour, E. & Hewitt, N.M. (1994) .Talking about leaving; Factors contributing to high attrition rates among science, mathematics, and engineering undergraduate majors.. Final Report to the Alfred P. Sloan foundation on an ethnographic Inquiry at Seven Institutions.   Boulder, CO: Ethnography and Assessment Research, Bureau of Sociological Research.

[23] Wilson, B.C. and Shrock, S. Contributing to success in an introductory computer science course: A study of twelve factors. In R. McCauley and J. Gersting (Eds.), The Proceedings of the Thirty-second SIGCSE Technical Symposium on Computer Science Education (pp. 184-188). New York: ACM, 2001.

[24] Guzdial, Mark, Ludovice, Pete, Realff, Matthew, Morley, Tom, Carroll, Karen, and Ladak, Akbar .   The challenge of collaborative learning in engineering and math.. In Proceedings of IEEE/ASEE Frontiers in Engineering (FIE) 2001 Conference. IEEE, Reno, NV, October 2001, IEEE; and available at http://coweb.cc.gatech.edu/csl

[25] Director, Stephen W., Chair, Engineering Dean's Council American Society of Engineering Education, Testimony to the Commission on the Advancement of Women and Minorities in Science, Engineering, and Technology Development, Washington, DC. July 20, 1999.

[26] Leventman, Paula G., What Happens After College., Part of the International Engineering Foundation Conference on Tackling the Engineering Resources Shortage, Montreal, Quebec, Canada, July 1998

[27] Becker, G. S. (1991). A Treatise on the Family. Cambridge, MA: Harvard.

[28] England, P., & Farkas, G. (1986). Households, Employment, and Gender. New York: Aldine Publishing Company.

[29] Spain, D., & Bianchi, S. M. (1996). Balancing Act: Motherhood, Marriage, and Employment among American Women. New York: Russell Sage Foundation.

[30] Rindfuss, R. R., Swicegood, C. G., & Rosenfeld, R. A. (1987). Disorder in the life course: how common and does it matter? American Sociological Review, 52, 785-801.

[31] Gujarati, Damodar N. 1988. Basic Econometrics, 2nd Ed. New York: McGraw-Hill, Inc.

[32] Allison, P. D. (1982). Discrete-time methods for the analysis of event histories. In S. Leinhardt (Ed.), Sociological Methodology (pp. 61-98). San Francisco: Jossey-Bass.

[33] Allison, P. D. (1995). Survival Analysis Using the SAS System: A Practical Guide. Cary, NC: June 9, 1997. Sas Institute, Inc.

[34] Yamaguchi, K. 1991. Event History Analysis. Newbury Park, CA: Sage Publications, Inc.

DONNA LLEWELLYN
Dr. Donna Llewellyn is the Director of the Center for the Enhancement of Teaching and Learning and an adjunct associate professor in Industrial and Systems Engineering at Georgia Institute of Technology. Donna received her Ph.D. in Operations Research from Cornell University. Her current areas of research are in equity of engineering education, and assessment of instruction. Donna is the PI of the APSIT NSF grant.

MARION USSELMAN
Dr. Marion Usselman is a Research Scientist at the Center for Education Integrating Science, Mathematics and Computing (CEISMC) at Georgia Institute of Technology. Marion received her Ph.D. in biophysics from Johns Hopkins University and has taught in the Biology Department at the University of North Carolina, Charlotte. She focuses on equity issues in education, and K-12 educational reform. Marion is a co-PI of the APSIT NSF grant.

MONICA GAUGHAN
Dr. Monica Gaughan is an Assistant Professor in the School of Public Policy at Georgia Institute of Technology. Monica received her Ph.D. in Sociology from the University of North Carolina at Chapel Hill. Her current research interests include the study of the career and life trajectories of scientists and the effects of gender on these paths.