

Casting a Wider Net: A Longitudinal Study Exploring Gender Differences, Influences and Attitudes Impacting Academic Major Selection in Computing

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Abstract

In this article data from a multi-year, longitudinal study of undergraduate students' attitudes influencing major selection in computing fields is examined. In particular, the observed differences between male and female students were examined. Different perspectives were found in the areas of stereotypes, timing of exposure to a major, experience with technology, outside influences, and program requirements. The results suggest there are several factors that should be considered by departments wishing to improve their marketing and promotion to prospective male and female students.

Keywords: Major selection, Gender imbalance, Stereotypes, IT workforce

1. Introduction

An ongoing topic of interest for Information Technology and related computing sciences is the low level of participation of women in the profession. During the 1980s, women earned almost 40% of the bachelor's degrees awarded in the various computing fields. That number has steadily eroded over the past two decades dropping from 29.9% in 1991 to 17.7% in 2008 (Hill, 1997; NSF, 2011). This decline has occurred not just in academia, but in the professional realm as well. In the late 1980s women made up 38% of the computing workforce in the United States. However, the number of females in the field has been in constant decline since that time (Misa, 2010). This trend is often met with confusion as, during the same period the technology industry has grown significantly and continues to provide a rich variety of employment opportunities

A number of studies have been conducted in recent years examining different facets of this issue (Camp, 1997; Margolis, 2002; Vesgo, 2005). This activity has yielded a number of possible explanations for this enrollment decline as well as a variety of suggestions for how to overcome the problem. In spite of these, however, none seems to be the 'silver bullet' and a lack of female students still plagues most computing departments.

Although the economy has not fully recovered from the recession of the late-2000s and unemployment is still a matter of concern, the technology sector continues to be a fast-growing career options (see Figure 1). President Obama recently reported that most positions have four job seekers for every opening, but the opposite is true for science and high-tech fields where businesses report difficulties finding suitable workers (Obama, 2011). The Bureau of Labor statistics predicts that technology will continue to be one of the fastest growing occupations in coming years (BLS, 2011). Furthermore, there is a growing concern among HR managers that an aging workforce is beginning to adversely affect technology companies. Industry trade association CompTIA estimates that nearly one third of these current employees are now, or soon will be 50 years or older (Summerfield, 2006). All these factors strongly suggest that demand for technically-skilled professionals should increase in coming

years. This also represents a unique opportunity to attract and retain a diverse IT workforce. As such, a worthwhile question to ask is how best to position and market a major in Information Technology or a related computing field and help improve the visibility and perception of a career in the discipline.

This study seeks to identify different perceptions, concerns, and motivations for females who may be considering a technology career. In particular, a key objective is to identify specific determinants of both major selection and rejection from which relevant marketing messages may be crafted. The design and results of the study are presented with recommendations that may prove useful to computer-related academic programs seeking to boost their number of female majors.

The field of Information Technology has changed the way many industries function and investment in, and reliance on technology has created tremendous employment opportunities. After a slowdown during the economic crisis of 2008-2009, forecasts suggest a rebound of increased IT spending in the coming years. Forrester Research predicted that the business and government investment in technology and related services would be \$1.6 trillion in 2010 (Yates, 2010). Employment forecasts for the next decade continue to be positive in spite of the evolving nature of the IT field (BLS, 2011).

Enrollments in computer-related majors have grown substantially since Purdue University offered the first computer science degree in the US in 1962 (see Figure 2). What immediately stands out are the two spikes: one during the personal computer revolution of the 1980s, and a second following the dot-com expansion of the early 2000s. Even without these surges the data still shows a strong steady growth over time (Zweben, 2011).

It is interesting to note that during the 1986 spike, female students made up almost 40% of computing majors (Misa, 2010). However, female participation in information technology and computer science has since declined – in spite of subsequent periods of growth, strong job demand, and the second peak in the 2000s.

2. Related Work

The literature reports a number of studies that seek to better understand the issue of female participation and several authors have posited potential solutions (Pollacia & Lomerson, 2006; Crampton, Walstrom, & Schambach, 2006). Some of the findings suggest that the lack of interest on the part of female students is likely due to one or more factors. Some of these factors include: gender differences and stereotypes (Jagacinski, LeBold, & Salvendy, 1988; Rettenmayer, Berry, & Ellis, 2007), preponderance of male-oriented computer games (Hartmann & Klimmt, 2006), lack of female role models – both on faculty and within the industry (Pearl, Riskin, Wolf, & Wu, 1990), early access to computers (Carter, 2006), perceived ability/self-efficacy (Shashaani, 1993), perceptions of people in the industry being ‘geeky’ (Seminario, 1998), a sense that IT work is boring (Thomson, 2008), and differences in learning approaches (Shashaani, 1994).

Typically, the prescriptions offered are a function of the focus of the study. For example, if the findings suggest that a lack of suitable role models is a concern for female students the typical recommendation is that the academic unit should seek to hire a female faculty member or two.

In some cases, these recommendations seem to run counter to findings of other studies. DePalma (2001) suggests that the solution to the gender imbalance is to make computer science more like mathematics. However, subsequent research suggests that math is a dissuader for many female students.

Many of the studies that have examined the gender imbalance were conducted 5, 10, or 20 years ago (Jagacinski *et al.*, 1988; Ogozalek, 1989; Camp, 1997). As technology has evolved rapidly and become much more ubiquitous these earlier findings may not be as valid for college students as they once were. Today’s traditional-aged college student has been termed a “Digital Native”, referring to how younger people have grown up during a period when personal computers and the Internet have been widely available (Presnky, 2001). Computer ownership among college students today is approximately 88% (Smith, Rainie, & Zickuhr, 2011) and smartphone ownership approaching 48% (Smith, 2011). Recent surveys suggest that the old stereotype of computer professionals being introverted or ‘geeky’ may not be widely held anymore (Sieverding & Koch, 2009). Surveys of college-age students further indicate that the majority believes the information technology field is still lucrative in terms of career opportunities and earning potential (Pepitone, 2009).

With these changes in perception and growing employment opportunities a unique opportunity exists to expand and diversify enrollments in computer-related majors. Rather than trying to identify a potential cause for the gender imbalance and recommending a corresponding solution, the objective of this study was to identify key determinants of major selection and rejection for all potential students as well as differences in perceptions and motivations between female students and their male counterparts.

3. Method

This project is part of a larger longitudinal study conducted between 2003-2010. The larger study seeks to better understand the complex system of motivations that many students consider when choosing an academic major. Further, the larger study also seeks to better understand the key reasons why students reject certain majors (information technology/computer science in particular), even when the data suggest that the choice should otherwise be appealing.

The survey instrument was derived from prior work reported in the literature (Ogozalek, 1989; Noland, Case, Francisco, & Kelly, 2003; Croasdell, McLeod, & Simkin, 2011). Unlike some questionnaires that are only given to students who have already selected a particular major, this survey was administered to 897 participants of varied educational backgrounds. This population included a wide array of declared majors, undeclared, declared (but uncertain), and students at different points along the timeline of their undergraduate careers. 91.1% of the participants were traditional college-age students (18-24 years old). 54.5% of the respondents were male; 45.5% were female.

The survey asks about major selection, reasons why majors are or are not chosen, motivations, barriers to consideration, as well as demographic information about each respondent. The surveys were administered anonymously, the rationale for the study was explained, and respondents were told that their participation was strictly voluntary. Student workers processed and coded the data to further ensure a degree of isolation from the investigators.

The survey was repeated on several occasions between 2003 and 2010. The longitudinal nature of the study was designed to enhance the validity of the findings. As enrollments in technology majors have historically risen and fallen with trends in the industry, the repeated nature of the survey also sought to identify changes over time that may be due to economic or other conditions.

The data were broken out by gender to identify potential differences between male and female students with respect to college majors. These comparisons were the primary focus of this particular study. The objective was not to uncover a 'root cause' of the gender imbalance. Such attempts in the past have not been widely successful in terms of effecting changes in enrollment trends. Rather, the goal was to uncover potential marketing messages that could guide future communication with prospective students.

4. Results

Overall, both male and female students are similar in many respects with regard to the decision process used to identify a suitable academic major. However, the data indicates that there are some differences between males and females in the following areas: perceived stereotypes, timing, computing experience, outside influences, and program requirements. Each of these is subsequently discussed in more detail.

4.1 Stereotypes

Prior research suggests that stereotypes associated with people in the computer field are one of the reasons why female students may choose to pursue different fields (Carter, 2006). Images of people (mostly males) with ill-fitting glasses, pocket protectors, a poor sense of fashion, and weak interpersonal skills were common in popular culture during the 1980-90s. However, as computer ownership and usage has become more widespread such stereotypical images are less common.

Not only are some of these old perceptions outdated, but the data also suggest that females disagree more strongly than their male counterparts regarding some key stereotypes (see Figure 3). Female respondents disagreed with the notions that computer majors are 'nerds' and that as a group they tend to be less social than students in other fields. What is interesting to note is that the majority of female respondents still believe that computer majors will work as programmers, that successful computer majors have significant technology background, and that most computer majors are devoted computer hobbyists.

This suggests that although negative stereotypes may have been a factor some years ago, these perceptions are evolving and the image people have of computer professionals is becoming more positive. As more female students grow up with computers the lack of a technical background should be less of an impediment. That said, computing departments should still be aware of these stereotypes and continue to avoid them whenever possible. Images of professional-looking females on recruiting literature, websites, and other communication channels will have a more positive effect than photos of Bill Gates, Mark Zuckerberg, or scenes from Dilbert cartoons.

4.2 Timing of Major Selection

Some students enter college with a firm idea about the field they want to study. Many others are undecided and use their early college experience as an opportunity to explore different majors. Departments have long used

introductory classes as a recruiting tool and both male and female students indicate that such courses do play a role in their decision process. However, this exploratory process cannot go on forever. In order to graduate in a timely manner, a student needs to make a decision and start taking classes specific to a particular major. As students earn more credits towards graduation a point is reached where the switching costs associated with changing majors become too high. At this point, students become committed to their choice and unlikely to change their field of study.

The data suggest that female students are more open to changing their majors than their male counterparts, but that they are also more sensitive to high switching costs. In particular we found that for students pursuing a four-year (eight semesters) baccalaureate program (see Figure 4):

- Females are more likely than males to change majors if the switch costs them no more than 1-2 additional semesters to graduate.
- Females are equally likely as males to change their major if the switch costs them 3 additional semesters to graduate.
- Females are less likely than males to change majors if the switch costs them 4 or more additional semesters to graduate.

The implications of this can be significant. Programs seeking to increase their female enrollments should target prospective students early in their college career. Female students showed more willingness than males to attend school for one additional year (two semesters) to pursue a major they are interested in. However, females quickly became much more averse to switching majors if their graduation plans were delayed any longer.

If a department relies on an introductory/survey course as part of its recruiting strategy it should make every effort to position the class as early in a student's academic career as possible. Some Information Systems programs in business colleges offer their introductory courses during the junior year. For many students this may be too late for them to consider changing their major.

4.3 Work Experience

Students are often influenced not only by their academic experiences, but by their work experience as well. Exposure to different industries and various functions within an organization afford students an opportunity to discover career paths that may or may not be suitable for them.

The data suggest that female students are more significantly influenced by their past work experience than male students – particularly in terms of that experience guiding their career and major choices. Respondents who had been exposed to and involved with information technology in some capacity while on the job were much more open to the possibility of pursuing a career in IT than those without such exposure.

College faculty cannot control where students choose to work while in high school or during their early years in college. More commonly, faculty are involved with students who have already selected a major in and are seeking a co-op, internship, or full-time position. However, some of the anecdotal feedback collected as part of the study suggests that students are very interested in better understanding professional life and preparing for it as part of their college career. Time spent talking about how organizations function, allowing students to share their work experience with the class, or inviting appropriate guest speakers from industry can all have a positive effect.

4.4 External Influences

Prior studies examining the major-selection process have suggested that external influences such as parents, high-school guidance counselors, roommates, etc. all contribute to a student's choice of academic major. However, our data suggest that these external influences may not have as much effect as they once did – particularly for female students. Females rated 'Family' very low in terms of influence on major choice. Other external influences that were rated as having minimal influence included "Freshman Seminar" courses and Career Aptitude Tests/Surveys.

These findings may be of interest to academic units that rely on a freshman seminar/orientation course as part of their marketing strategy. For the purposes of the study this class is defined as a broad-based course offered by the institution that introduces students to a wide variety of majors, teaches basic study skills, and covers topics related to college life. Many colleges offer such courses as they seem to help with retention efforts, but heavy reliance on them may not be an optimal recruiting strategy – especially if the objective is increased female participation in a computing program.

The reason for the drop in traditional external influences was not captured in our data. One might speculate that today's Digital Native students are still influenced by external forces, but that those external influences are now much broader than traditional groups. This remains a hypothesis for future study.

4.5 Negative Program Requirements

The requirements associated with admission to an academic major can be structured in such a way as to limit enrollment numbers or restrict admission to higher-performing students. Minimum grade point averages, pre-requisite courses, and entrance exams are sometimes used as rationing mechanisms for popular majors.

In cases where enrollment numbers are lower than desired the requirements for admission should be carefully scrutinized and reviewed for suitability. The data indicates that prospective female students view three common program requirements negatively:

4.5.1 Calculus/Advanced Mathematics

Both male and female students tended to rate calculus and other advanced math courses as a negative factor in their major-selection decision. Advanced math, for the purposes of this study, is any math course above what is required for all students by the institution. Female students, in particular, found a calculus requirement to be particularly burdensome and rated it more negatively than all other factors in the survey. (Note: The data says nothing about the success of female students in Calculus or advanced math, and it would be inappropriate to interpret the data as supporting the stereotype that females struggle with mathematics. What the reader should take away from these findings is that, for whatever reason, female students view advanced mathematics as a negative factor in major selection).

4.5.2 Hard Science

Prospective female majors also rated a hard science requirement (e.g., Chemistry, Physics, etc.) as being a negative factor. In follow-up discussions with the respondents we found the matter of a science requirement similar to that of math. If a particular science course is required of all students at the institution then other potential academic programs are no more or less attractive in this regard. However, a major that requires one or more hard science courses beyond what the institution's minimal requirements put itself at a disadvantage when recruiting female students.

4.5.3 Computer Programming

Many computer-related majors begin their curriculum with one or more courses in computer programming (ACM, 2001; ACM, 2005). Software development is the foundation for more advanced topics in the field and these courses are often key pre-admission requirements. Computer programming has also been a traditional entry-level path into the profession and college students with good coding skills frequently find lucrative part-time employment while in school.

The majority of both male and female respondents indicated that they did not particularly enjoy computer programming and viewed it as a negative factor in their major-selection decision. Female students in particular expressed a strong aversion to programming early in their major program of study. During follow-up discussions with the respondents we asked them to identify better alternatives. Courses such as web design, social implications of technology, and computer security were commonly identified as more attractive starting points. Although not part of the original survey, the anecdotal feedback received seemed to suggest that programming courses would be viewed less negatively if introduced later in the major.

4.6 Positive Requirements

Female respondents did rate two program requirements particularly highly. An internship or co-op requirement as part of the major had the highest rating. Male students also see such a requirement as being positive, but not to the extent female students do. If an academic department has a well-organized internship program it should be prominently featured on their web site and promotional materials.

Prospective female students also rate a public-speaking requirement very highly. In contrast, many male students view such a course with reservation. Some institutions require public speaking as part of their general-education curriculum. For those at schools that do not have such a requirement it may be valuable to include a public-speaking class as an elective course for the major. By making it an elective, those who are averse to public speaking may choose to avoid it. Those that see it as a positive can include a course as part of their program of study.

5. Discussion

This study seeks to better understand the motivations students have when considering their choice of an academic major. In particular, the study identified several key areas where prospective female students differ

from male students. The data collected suggest that although perceptions and motivations were generally similar, there are marked differences in the areas of stereotypes, timing, experience, outside influences, and program requirements. None of these alone is likely to be the key reason for the steady decline in female participation in the computing field. Rather, each are things to consider when evaluating the academic program and its associated marketing and recruiting messages.

Although the data were collected from a diverse pool of respondents and replicated over a period of seven years, the degree to which these findings can be generalized to other institutions should be carefully considered. Academic programs seeking to increase their number of female majors should actively try to identify what motivates the local students and tailor their messages accordingly. Such market research should be an on-going initiative as the data shows a shift in response patterns over time. As technology continues to become more integrated into peoples' lives, new technological fields emerge, and opportunities in different regions evolve, departments need to adapt to make their program as relevant and appealing as possible.

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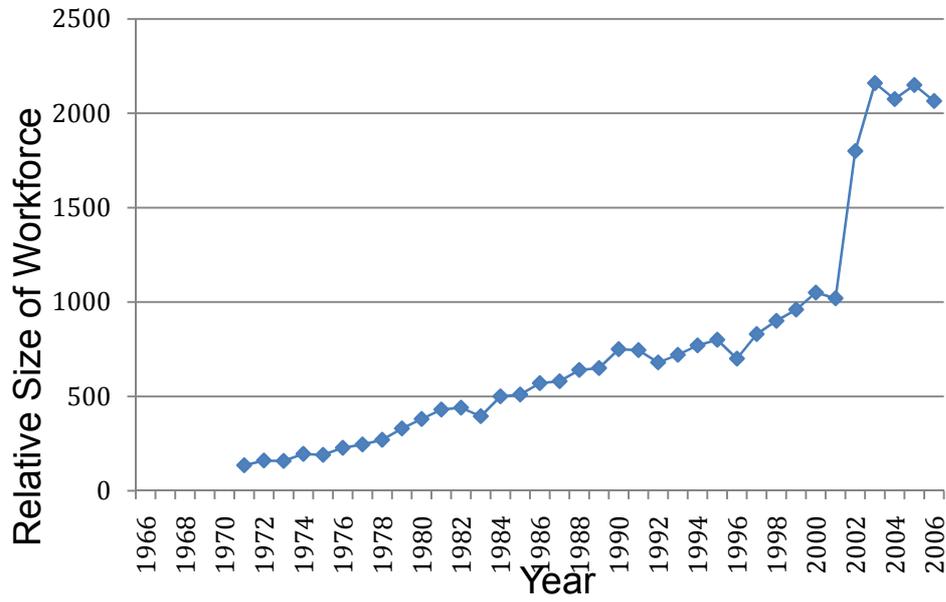


Figure 1. Growth in the Computing Workforce in the United States

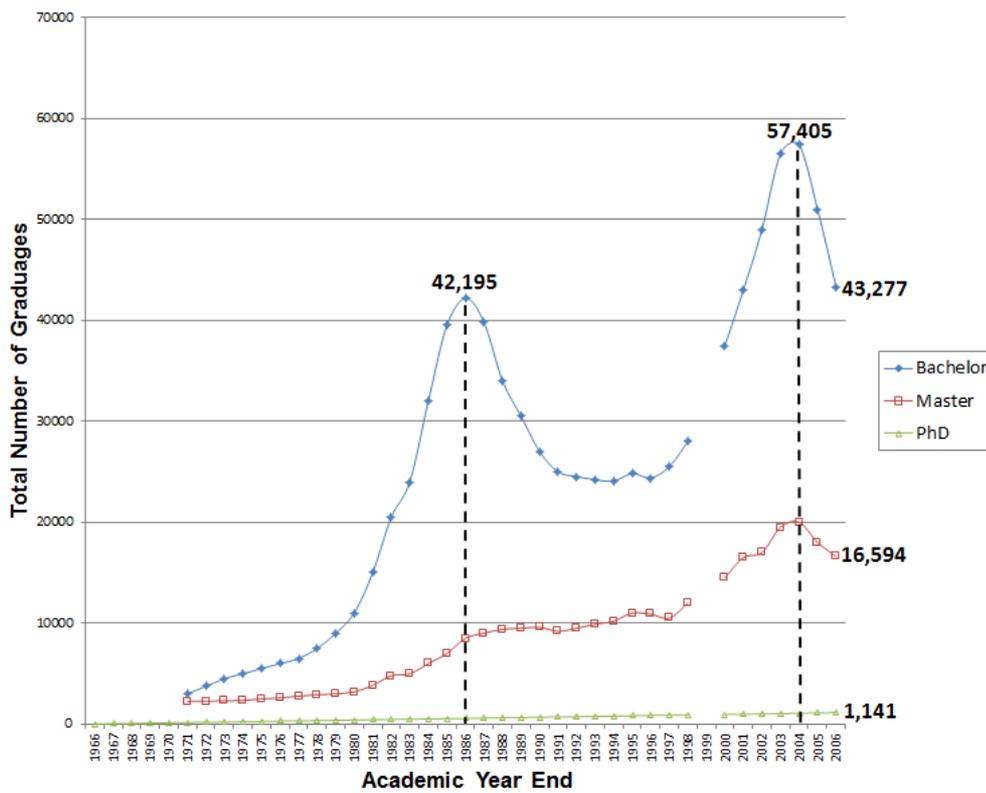


Figure 2. Total number of graduates

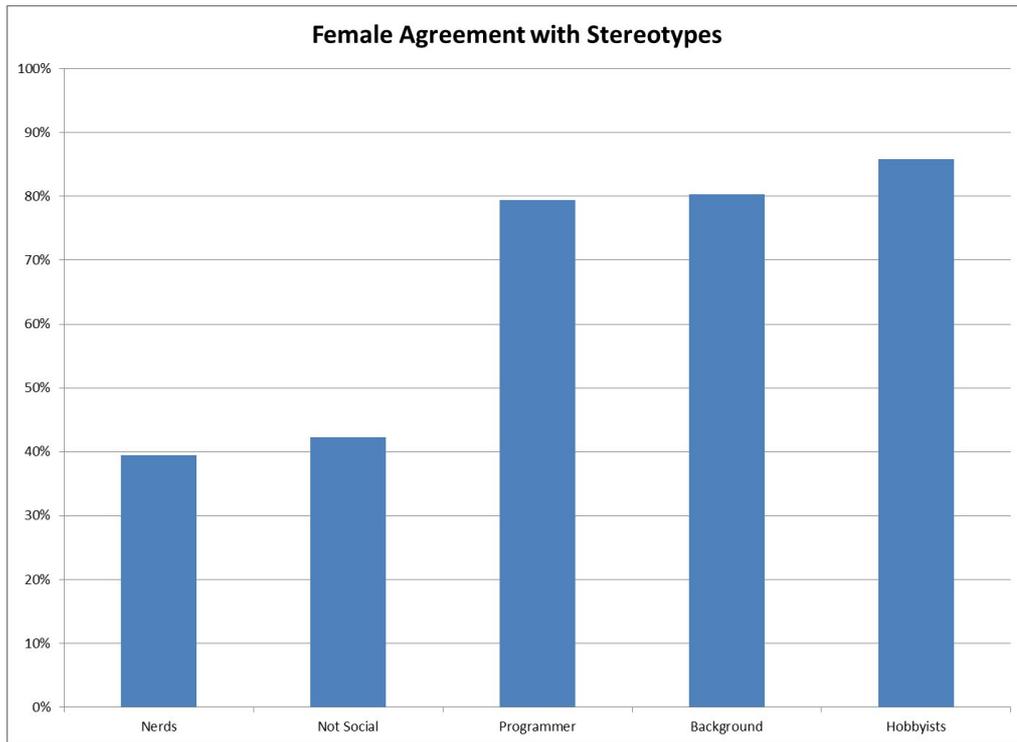


Figure 3. Female Perception of IT Stereotypes

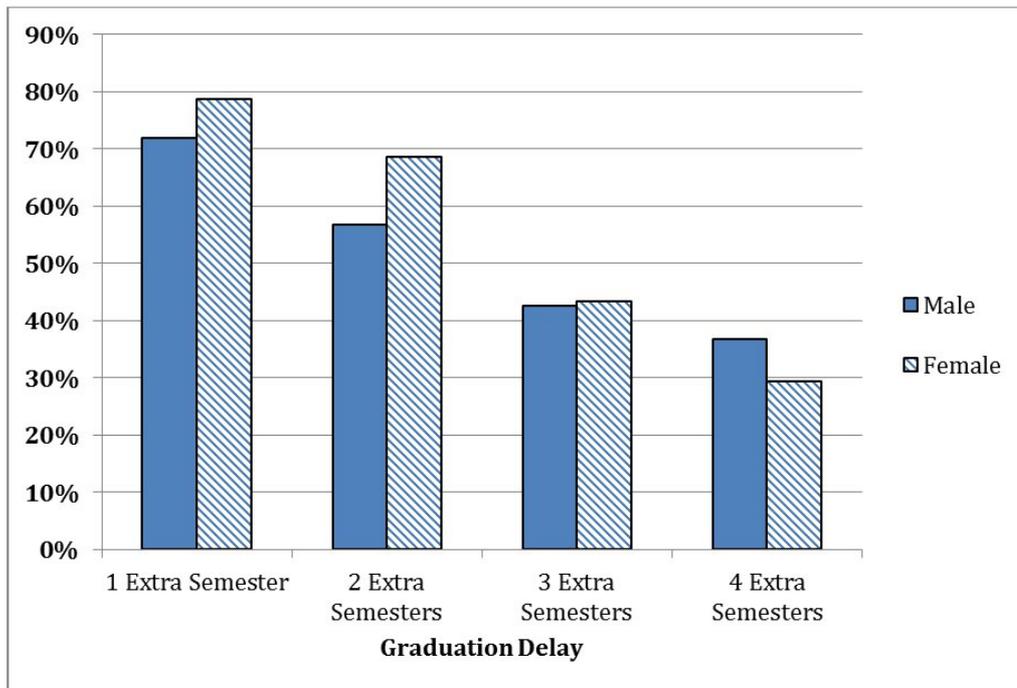


Figure 4. Willingness to Change Major if the change causes a Delay in Graduation