Females and Computing Majors in the US: Why is the Choice Still Unappealing?

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Abstract. This report examines the motivations and distractors that influence women's decisions to study and pursue careers in computer technology. This is an important aspect of the gender divide that western economies are experiencing in the computing field. Numerous research studies have explored this imbalance in the past, and many of the findings are routinely cited in the literature. However, technology is a field that changes rapidly, and societal acceptance of computers and technology have also evolved. Gen-Z students have grown up with computing technology and their perceptions of it may well be different from those of students a decade or two ago. This paper reports on a study that seeks to measure changes in perceptions over time and which factors seem to hinder. The findings may be helpful for academic departments that are seeking to expand female enrollments in their computing majors.

Key words: females, computing majors, US, computer, female enrollment, computer science.

Introduction

This history of the modern computer is tightly woven with the role of women in its growth and development. Prior to the invention of the electronic computer, the term itself referred to mathematically-skilled individuals who worked for academic, engineering, and governmental employers performing complex analyses. By the time the first electronic computers were built, most human computers were female (Blitz, 2017: 58-59). The development team that programmed the first general-purpose electronic computer during World-War II (ENIAC) were mostly women. These early programmers developed the algorithms for complex artillery trajectories and other war-related tasks. After the war ended, the commercial computing industry began and throughout the 1950-60-70s women were heavily involved in computer programming and operations (Smith, 2013: 1-9).

The 1980s brought significant change to the computing industry. The personal computer emerged from its toy-like status of the late 1970s as a serious business tool and freed people from their reliance on large mainframe host computers. During the 1970s and early 1980s, computer science was one of the fastest-growing areas of study for female college students. In 1984, women earned approximately 40% of the degrees in computing in the US (see Fig. 1). From that point forward, however, female participation in computing has steadily declined dropping to 30% in 1990 and 18% in 2014 (Accenture, 2016).

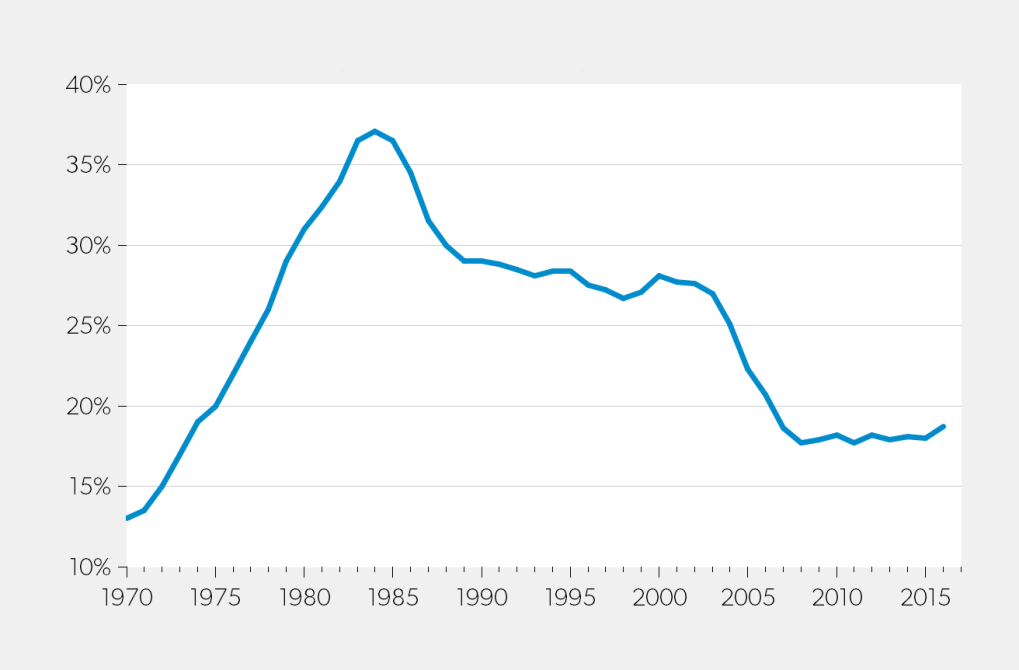

Fig. 1. Female Enrollment in Computer Science

If the overall computing field were in a state of decline, this trend would not be such a matter of concern. However, at nearly $2 trillion in economic output, the technology sector makes up approximately 10% of the U.S. economy and employs over 12 million people (CompTIA, 2020). As a result of this growth in technology and employment opportunities, enrollment in computing majors' popularity has been strong for decades, with encouraging forecasts for continued growth in the future (National Center for Educational Statistics, 2020). Still, in spite of the growth in the field, and the higher salaries that computing professionals enjoy, fewer women are choosing computer-related majors in college.

The declining trend is not limited to college enrollments, but also includes employment in the computing field as well. In the mid-1980s, women held 38% of the computer workforce positions, but have steadily declined since then (DePalma, 2001: 27-29). Although the computer industry's job creation rate in the U.S. is three times higher than the national average, if current trends continue, estimates are that women will occupy fewer than 20% of computing jobs by 2025 (Accenture, 2016). This is particularly troubling as the computing workforce in the US is aging and demand for new skilled workers is growing. In 2006, a CompTIA study indicated that one third of the computing workforce was nearing 50 or older (Summerfield, 2006). As shown in Fig. 2, by 2021 45% of the workforce was approaching the 50 and over category (CertMag, 2021).

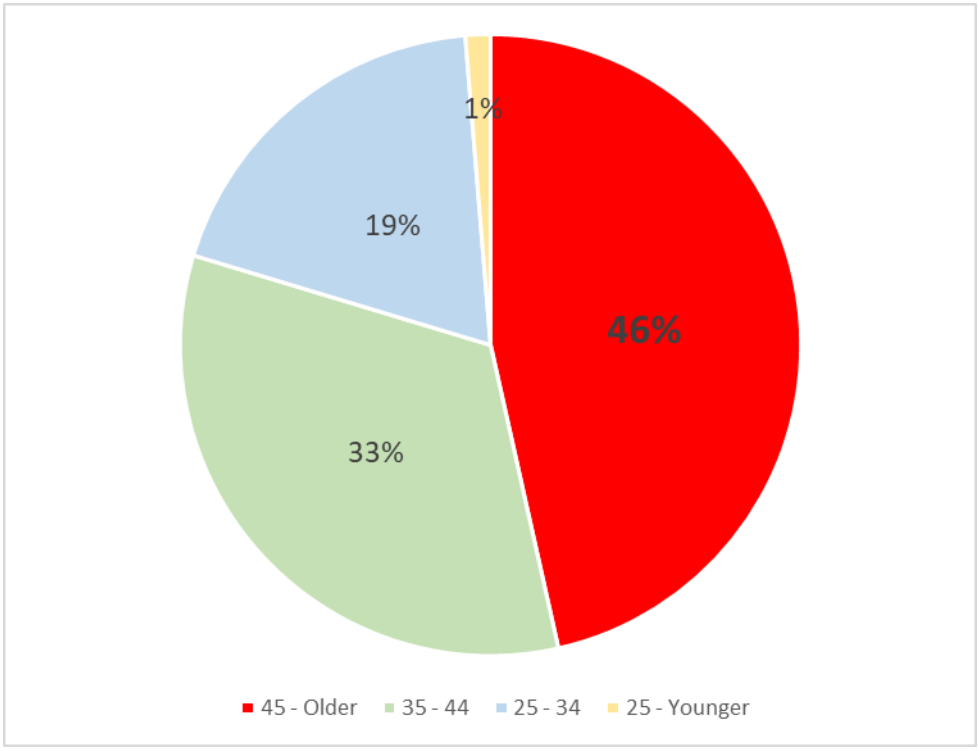

Fig. 2. Age of U.S. Computing Professionals 2021

The decline in females opting to major in computing technology is more problematic in western countries than in other parts of the world (Schinzel, 2017). Female students in India make up 45% of the enrollment in computing majors, almost three times the amount seen in the U.S. (Thakkar et al. 2018). In 2015, the majority of internet business startups in China were headed by women. In Saudi Arabian universities, females make up nearly 60% of the enrollments in computer science (Alghamdi, 2016).

This phenomenon has been a matter of concern both for academic computing departments and human-resource offices for many years. Over several decades, research studies have identified a number of presumed root causes for this disparity and associated solutions have been proposed.Despite this research, as well as significant interventions by both industry and academic groups, the trend continues (Bowles, 2012: 189-212; Vitores and Gil-Juarez, 2016; Vitorez and Gil-Juarez, 2016: 666-680). Many of the frequently cited studies were conducted a number of years ago (e.g., Camp, 1997: 103-110; Clarke 1992: 71-86; Cohoon, 2002: 48-52; Cooper and Weaver, 2003: 56-79; Jagacinski et al., 1988: 185-202; Ogozalek, 1989: 8-14; Schinzel, 2017: 87-89; Symonds, 2000: 241-249). Computer technology changes rapidly and its relationship to society and culture has also shifted dramatically over the past three decades. Modern “Gen-Z” students have grown up with technology and cannot remember a time when computers weren’t ubiquitous. Although the gender divide still exists in computing majors, are the underlying reasons for females choosing other academic options still consistent with prior research findings? The objective of this study is to examine the literature and contemporary student feedback to determine if the established assumptions about female enrollment in computing programs of study are still valid. In particular, we seek to better understand the determinants of major selection and rejection and how those may be useful to computer-focused academic programs that are seeking to boost their female enrollments.

Material and Method

Background

Over the years, a number of researchers have studied the dramatic decline in female participation in computing (e.g., Camp, 1997: 103-110; Margolis and Fisher, 2002: 174; Vesgo, 2005; Pollacia and Lomerson, 2006: 220-225; Crampton et al., 2006: 226-230). These studies have identified several different issues that are believed to significantly contribute to the decline in female representation and have offered prescriptive suggestions on how the problem might be overcome. The research findings suggest that the lack of interest by female students is likely due to one or more factors. Some of the most commonly cited factors include:

1) a lack early access to computers
2) limited computer coursework in high school
3) a preponderance of male-oriented computer games
4) stereotypes of people in the industry being 'geeky'
5) a lack of suitable female role models
6) career perceptions - computer work is mundane

Lack of early access to computers

Significant differences in ownership, access to, and use of computers at early ages (i.e., pre-high school) by boys and girls have been associated with differences in their attitudes towards computers (Main and Schimpf, 2017: 296). In 1984 only 5% of adult women and 19% of girls were using a computer at home. In contrast, 25% of adult males and 51% of boys were using computers (MacDonald, 2014: 122-128). These disparities early in a person's development are thought to contribute to the differences currently seen between males and females and their consideration of computing programs of study (Adya and Kaiser, 2005: 230-259).

Limited early coursework in computing (high school)

Research has shown that women tend to be further along in their academic studies than males when they take their first computer course (Sax and Harper, 2007: 669). Female students are also less likely to have taken computer courses in high school (Goode et al., 2013: 46). This lack of early exposure to computer technology, particularly during formative years, is thought to contribute to the lack of computing participation as an academic major and career later in life (Cooper 2003).

Male-focused computer games

Computer games have been a major part of the computing industry since Atari released the first commercially successful video game in 1972. Throughout the history of the personal computer, the majority of games have been overtly developed for and marketed to males. This trend continues with only a minority of computer games having a female protagonist (Sarkeesian and Petit, 2019). Prior to the Internet and its associated applications becoming publicly available, computer games were the most popular use for personal computers by young people. Researchers have suggested that by making the computer more appealing to boys in the past, the gaming industry contributed to the gender gap that we see today (Andrews, 2017; Coyle, 2017)

Stereotypes about those in the industry

Negative stereotypes about computer students and professionals, sometimes referred to as the 'nerd factor', are often cited as a key reason why women choose not to pursue technical careers (Cross, 2005; Ernesto et al., 2014: 4403; Ehrlinger et al., 2017: 40-51). For many years, media and popular culture portrayed computer users as almost exclusively male, socially awkward, introverted, and unfashionable (Kendall, 1999: 260-283; Cheryan et al., 2013: 58-71; Kadijevich, 2000: 145-154). These characteristics

contrast sharply with traditionally feminine values and make computing less appealing for prospective female students (Lippa, 1998: 996-1009; Su and Rounds, 2015).

Lack of female role models

The decline of women in computing occupations has led to fewer female role models for girls who may be considering careers the field. Researchers have suggested that this lack of visibility and external influencers contributes to the gender gap in tech occupations (McBride, 2015). The lack of women in the profession also corresponds with a low percentage of female college faculty in the computing fields (Grier, 2013).

Career perceptions – computing is mundane

In 2014, Google detailed a study examining the factors that most significantly influenced a students' choosing or rejecting a computer major and career (Google, 2014). In addition to social encouragement, role models, and academic exposure, the study found that the second most crucial factor for a young woman considering a computing career is their perception of the field and associated occupations. Females who were not familiar with computing tend to view it as tedious and laborious (Kadilevich, 2000; Google, 2014). Perceptions like this lead otherwise well-suited individuals towards other career paths (Margolis et al., 2000).

These prior research studies examine different aspects of the problem and most focus on a single cause for the decline (e.g., there is a lack of positive female role models). The associated solution included in the report typically calls for an associated change in what is reported as the cause (e.g., universities should hire more female computer science faculty members). Despite this research effort, the trend continues and none of the prescriptions have either been effectively implemented or shifted the outcome (Vitores and Gil-Juarez, 2016).

Methodology

This project is part of a longitudinal study conducted between 2003-2020. The broader study surveyed traditional-aged students to better understand the motivations behind student selections of an academic major. In particular, the research attempted to identify why students reject information systems and computer science majors in the face of strong employment opportunity. The survey was based on prior work reported in the literature (Ogozalek, 1989: 8-14; Lippa, 1998: 996-1009; Kadilevich, 2000; Noland et al., 2003: 150). Often, surveys of this sort are administered to students who have already selected a particular major. Convenience sampling of this sort can yield distorted results. For this study, the questionnaire was administered to 943 participants between 2003 and 2020. Respondents were drawn from diverse educational backgrounds including students from various academic programs, declared and undeclared majors, and different school years (freshmen – senior). 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 explores issues identified in prior research, perceptions about the computer field, motivations for major selection in college, reasons why technology majors are or are not chosen, and descriptive information about each respondent. The surveys were administered anonymously, the study's objectives were presented, and participation was voluntary. Student assistants coded the responses to provide a degree of isolation from the investigators.

Results

A key question in this investigation is if there have been shifts over the past two decades in terms of women and their perceptions of and relationship to technology, academic majors, and computing career opportunities. Responses were broken out by

gender and compared to each other. More recent data was also compared to the preliminary results that were reported in 2010 (Butterfield and Crews, 2012: 2). The results for each of the key influencing factors are presented below.

Lack of early computer access

Computer ownership has steadily increased over the past several decades and early access to computing technology has greatly expanded. Responses to the survey clearly suggest that gender disparities in early access to computers and related technology are no longer an issue in 2020. Both female and male respondents reported equal access to technology growing up at home, with 75% having a household computer (see Fig. 3). This result is consistent with U.S. Census data that estimates that 77% of U.S. households own a desktop or laptop computer (Ryan, 2018).

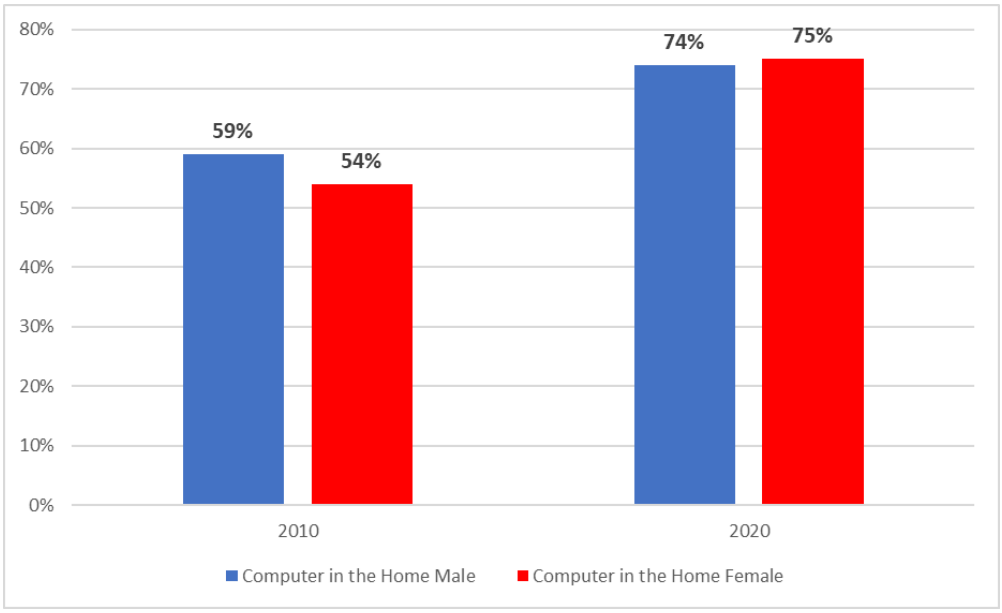

Fig. 3. Early Access to Computers

Limited early coursework in computing

The longitudinal data collected in this study shows a dramatic shift in terms of early computer coursework. Prior to 2010, the majority of respondents indicated that their high schools either didn't offer computer classes, or that such courses were electives (not required). In the latter case, boys were twice as likely as girls to take an optional computer class. By 2020, the majority of those surveyed indicated that computer classes were almost universally available at their high schools and that most required at least one course be taken (see Fig. 4). It should be noted that most of the respondents in this study grew up in a state that includes demonstrating technical competency as a requirement for graduation. A growing number of states have similar requirements and the availability of computer courses in K-12 is expected to further reduce the gender imbalance (Herold, 2018).

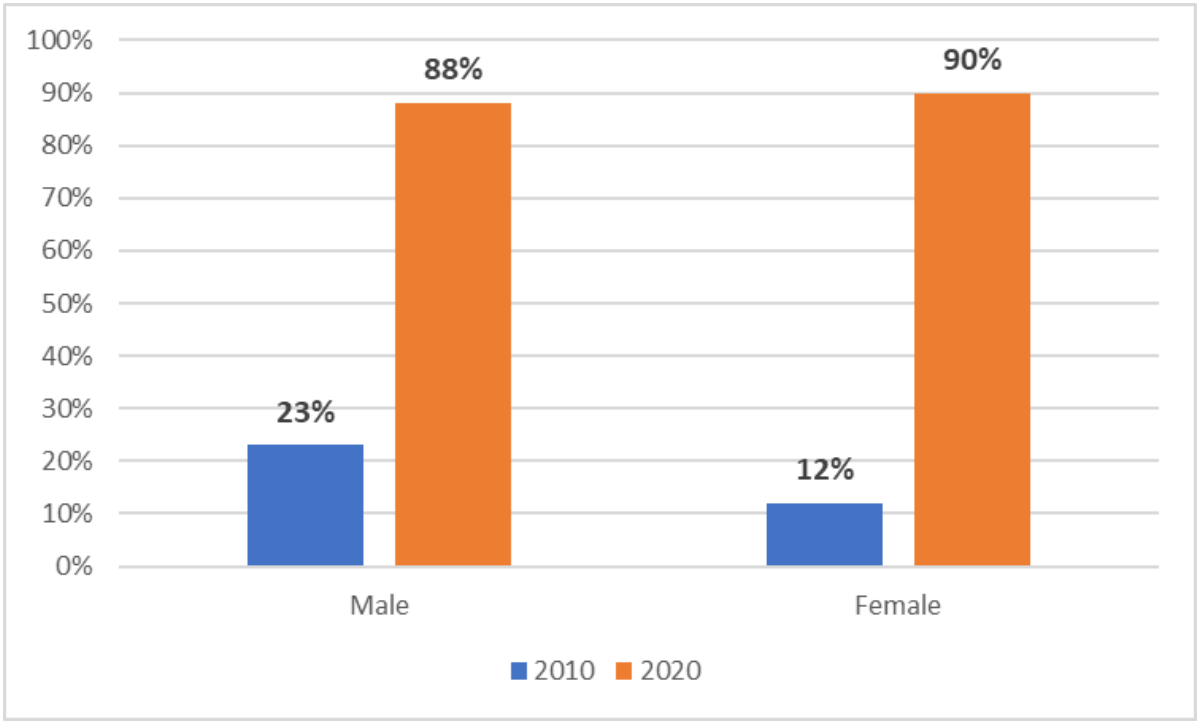

Fig. 4. Taken a Computer Course in High School

Male-focused computer games

Although games have long been targeted at male consumers, a growing number of females now identify themselves as either casual or serious gamers. The data collected in this study is consistent with broader research that suggests women may be catching up with men in certain aspects of gaming. In 2015, a study released by Pew Research showed that among teenagers, 97% of males and 83% of females owned a gaming console. This represents a significant narrowing over previously reported data (see Fig. 5). When people of all ages were considered, it was found that 37% of males and 42% of females owned a video-game console (Anderson, 2015).

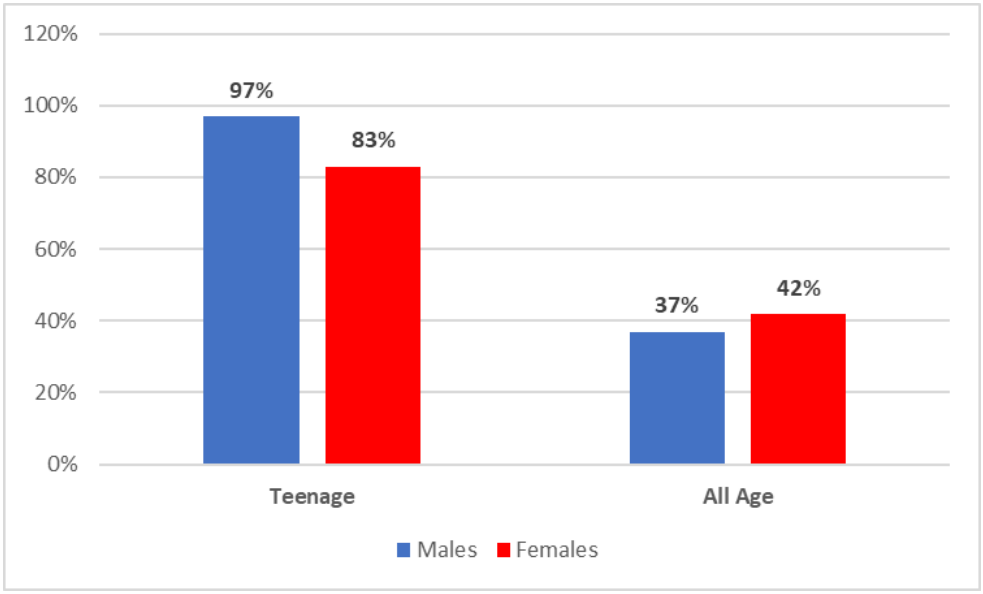

Fig. 5. Gamers by Gender

Stereotypes about computer users

The results of this study suggest that stereotype issues are less problematic than they may have been previously. Although stereotypes still exist, their negative impact appears to be less impactful. Of particular interest were the differences between male and female respondents. Findings indicate that female respondents disagree more strongly than their male colleagues regarding some key stereotypes (see Fig. 6).

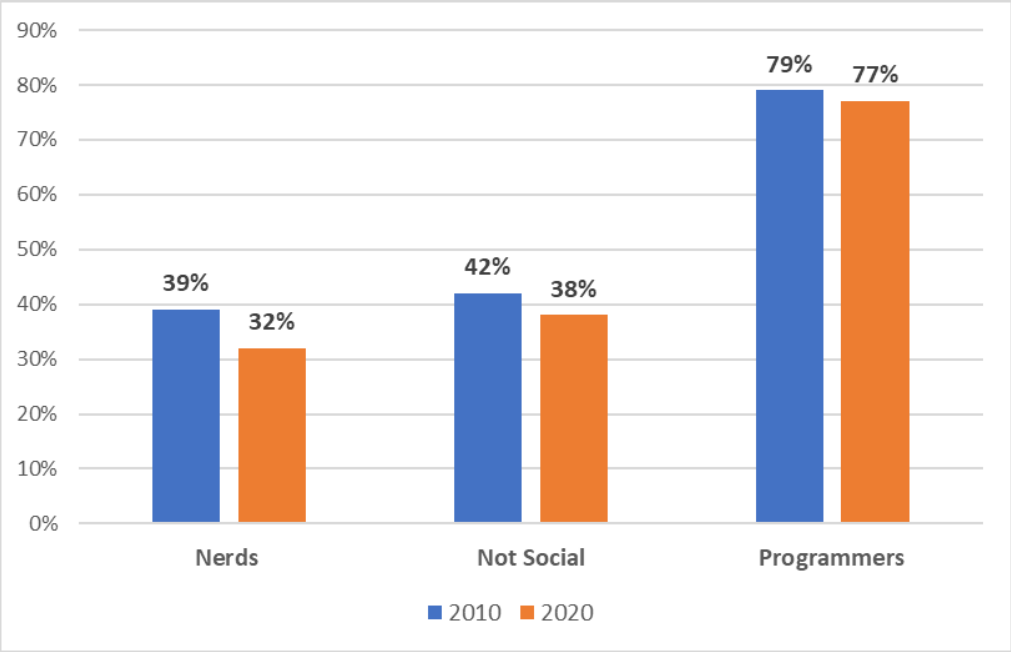

Fig. 6. Female Perception of I.T. Stereotypes

Over 60% of females 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. This change in perception may be due to the rise of the computer industry, the public awareness of many "nerdy" professionals accumulating large fortunes, and the widespread ownership and use of computers, smartphones, and related technology (Woyke, 2008). Over 75% of female respondents also believed that people who major in computers will go onto become programmers. This has implications for major selection that are discussed further in a subsequent section.

Lack of female role models

The lack of women choosing to study computing and work in the technology industry over the past several decades has resulted in fewer female role models who can serve as a positive influence for younger girls. This study confirms that this imbalance continues to be a problem, with most female respondents indicating that the lack of female visibility in technology has a negative effect on their perception of the field. Although not explicitly captured in the survey, subsequent debriefing indicates that the perceived lack of females in advanced computer courses in college creates somewhat of a vicious circle that discourages otherwise interested women from taking computer classes.

Career perceptions – computers are mundane

The perception that computing is an inherently dull subject and that work in the computing field is also dull and socially isolated is an opinion held by both male and female respondents. Between 2010 and 2020, the data indicates less of a difference observed between the sexes, but the perception still widely exists (see Fig. 7).

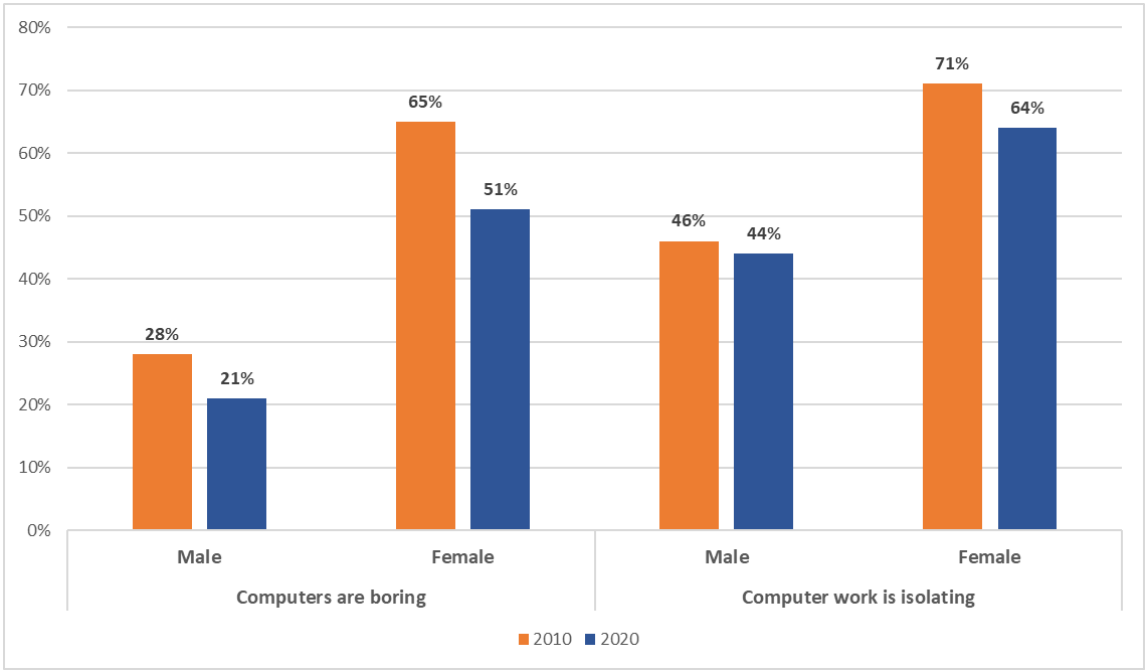

Fig. 7. Perceptions of Computing and Computer Careers

The data suggests that part of this may be grounded in how respondents view computer programming. The majority of both female and male respondents indicated that they did not enjoy computer programming and viewed required courses in programming as a negative factor in their major-selection decision (see Fig. 8). In particular, female students expressed a strong aversion to programming early in their major program of study. Approximately 75% of female respondents believe that computer majors will work as programmers after graduation.

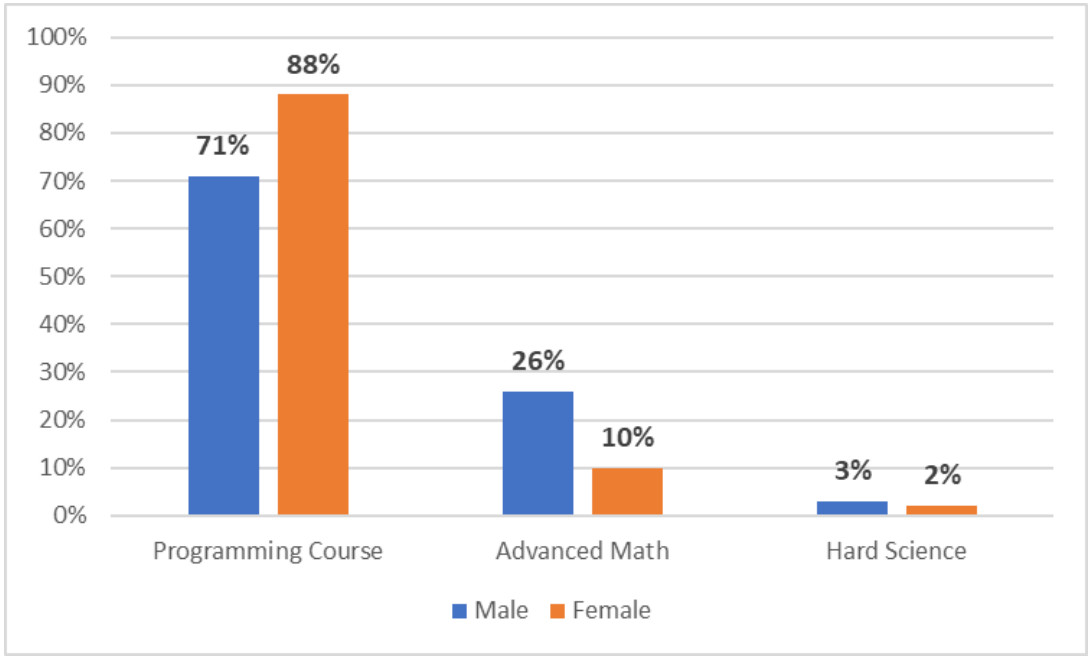

Fig. 8. Biggest Curricular Barrier to Major Selection

Programming courses are an important part of most computer curricula and are foundational to more advanced topics in the field. Many academic departments require

one or more programming courses as the introduction to the major (ACM, 2013). Such practice could adversely affect the number of female students who choose to study computing. Both male and female respondents indicated that introducing the major with more varied starting points (e.g., web design, social aspects of computing, data analytics) and deferring required programming courses until later in the program would make it more appealing.

One of the most interesting findings of the current study is that there was the difference between how respondents considered computing majors and careers in general and the extent to which they considered either for themselves. As shown in Fig. 9, students were asked if they had considered majoring in a computer discipline and working in a computing occupation. Then they were asked if these were good options, in general, for other students.

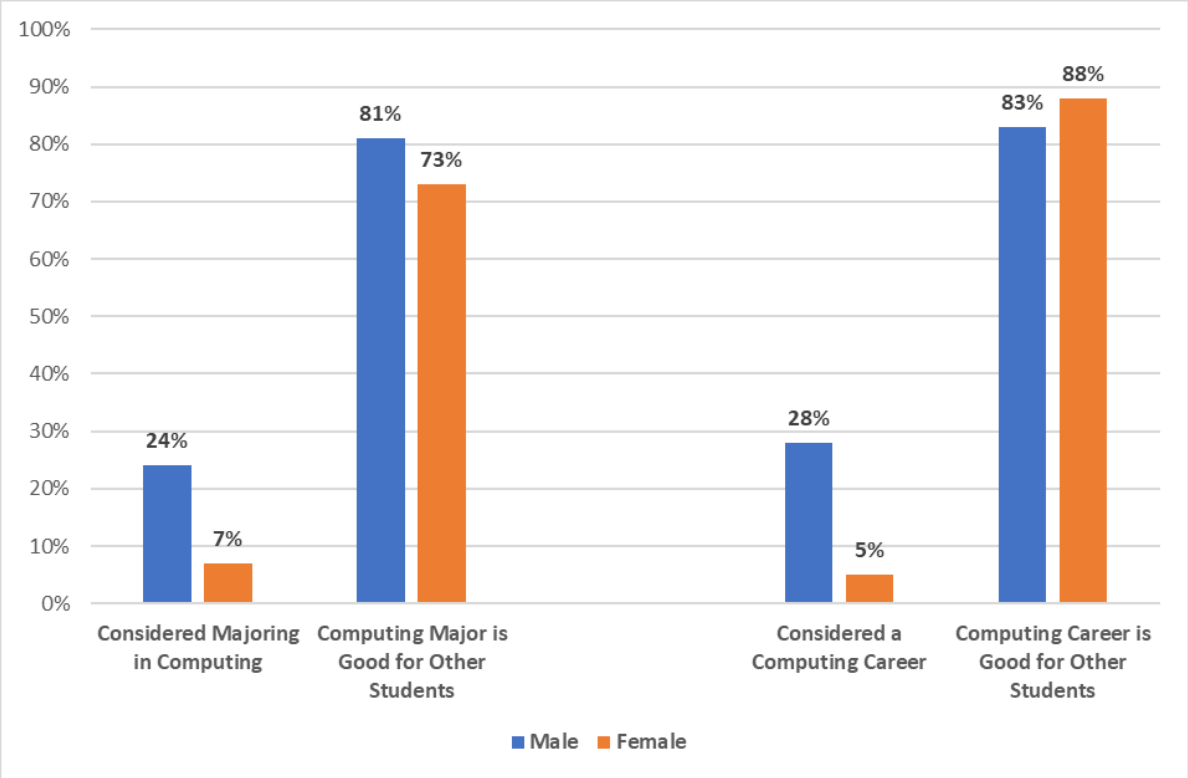

Fig. 9. Evaluating Computing for Self and Others

Conclusion

As computer technology continues to evolve and play a more important role in our personal and professional lives, the need for skilled computer professionals will continue to grow. The decline in female participation in computing is cause for significant concern. It is not the goal of this study to suggest an alternative explanation for the phenomenon, but rather to re-examine past research and the applicability of prior findings to contemporary Gen-Z students.

The data suggests that some of the earlier obstacles to computer interest are no longer as impactful as they may have been in the past. Negative stereotypes about people who study computers and work in the field still exist, but the perceptions are evolving with greater acceptance of so-called 'nerd' characteristics. Many computer games are still developed for the male market, but women are increasingly identifying themselves as gamers. The disparity that once existed for early access to computers and computer

classes is no longer an issue, and males and females both report equal ownership of personal technology.

Some obstacles that have been reported in the literature are still problematic. For example, the overall lack of women who study and work in computing creates a lack of female role models. This fact is a vicious-circle problem that will require significant intervention to remedy. A growing number of technology companies are starting to address this proactively and it's hoped that in time, this situation can improve.

Both male and female students considered computing a good option for a program of study and career for others. However, only a small percentage of female students reported that they had given either serious consideration for themselves. This suggests that although perceptions of computing and the computing industry have improved in recent decades, there is still a significant disconnect that is keeping women from fully participating in this field. More research needs to be done to better understand the motivations and concerns of Gen-Z students and how this gap can be closed.

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